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PROGRESS OF INVESTIGATIONS OF THE MARINE ANIMALS IN CHINA

DR. TCHANG SI
DIRECTOR OF THE INSTITUTE OF ZOOLOGY, NATIONAL ACADEMY OF PEIPING

TRACING the origin of the development of marine zoology in China, although such studies are just beginning, it may be said there are three periods. The first period is before 1800 A.D., during which time the records of marine animals are only present in the old books and not technically treated. During the second period, 1800 to 1929, a period in which foreign zoologists worked occasionally along the China coasts. After 1929 marks the last period, at which time our own zoologists began to work on this line, and there is already considerable progress. Before dealing with the details of each period, I give here a brief discussion on the characters of the China coasts which are important to marine life.

CHARACTER OF THE CHINA COASTS IN RELATION TO THE MARINE ANIMALS

There are seven provinces along the Chinese coasts, *viz.*, Liaoning, Hopei, Shantung, Kiangsu, Chekiang, Fukien and Kwangtung, with a sea-shore measuring about 7,000 kilometers and extending from 41° to 19° north latitude. The northern coasts are mostly with plain sandy bottom, while the southern ones have many bays and islands. The whole coastline is semicircular and can be geographically divided into four regions, namely: (1) Pohai Gulf, (2) Hwanghai (Yellow Sea), (3) Tunghai (East China Sea) and (4) Nanhai (South

China Sea). (1) From Lao-Tieh-Shan of Liaotung Peninsula southward to Chefoo Island of Shantung Peninsula, a distance of 90 knots, as a border line, to the west are the coasts of Liaoning, Hopei and Shantung, which all belong to the Pohai region; (2) from the estuary of Yalu River to that of the Yangtze River are the coasts of Liaoning, Shantung and Kiangsu, all of which belong to the Hwanghai region; (3) from the estuary of the Yangtze River southward to Chenhaikiao on the south side of Amoy, are the coasts of Kiangsu, Chekiang and Fukien, which belong to the Tunghai region; (4) from Chenhaikiao through Kwangtung coasts to the Estuary of Peilung River in the Gulf of Tungking, is the Nanhai region. Following is a discussion of the characters of these coasts emphasizing the places which are rich in animal life.

(1) Pohai region: Pohai is an inland sea embraced by the Peninsulas of Liaotung and Shantung, with an area of 22,803 square knots and a depth of water not greater than 25 fathoms. Due to the influence of continental weather, the temperature of the surface changes greatly, the average being 11° C. and the difference between maximum and minimum about twenty-six degrees Centigrade. The coloration lies on Forel's colorimeter No. 6, except the mouth of Taku River where the color is yellow, due to the influence of the river. Salinity is quite low, with a density of 1.0031, because of the large inflow from the rivers, such as Liao, Luan, Po, Yellow, etc. Though the coasts of Pohai Gulf are simple, there are the "Eight Islands of Changshan" in its mouth and thus an important area for fisheries. The Kühwa Island in Liaoning, Chinwangtao, Peitaiho and the mouth of Taku River in Hopei, the mouth of Litsin River, Hutouyai and Lungkow Bay in Shantung are all places with plenty of fishes and other aquatic forms. *Pagrosomus auratus* (Forster), *Scomberomorus gracileus* (Günther) and *Penulirus* are characteristic products of Pohai fisheries. Tenchow

Cape is not a favorable place for marine life, but both Chefoo Bay east of it, and the area outside the bay, are well populated. Chefoo is thus a suitable place for studying the organisms in East Pohai, and Peitaiho for west Pohai.

(2) Hwanghai region: From the mouth of the Yangtze River northward to the sea west of Korea, with an area of 112,032 square knots, the depth of water varies from 5 to 70 fathoms and the average temperature is 15° C. In the northern part, there are the inflows of Hankiang and Yalu Rivers, and in the southern part, those of Hwaiho and Yangtze Rivers. According to the reports of the Zoological Expedition of Kiaochow Bay (1935–36) the water outside the bay has a salinity of 31/1000, the coloration lies between No. 7 and No. 8 in Forel's colorimeter and the transparency 6.50 m and pH 7.5 (at 32° C.). Good places for zoological collection are mostly found along the coasts of Shangtung Peninsula which are more irregular than elsewhere. Weihaiwei, Changshantou, Yungcheng Bay, Moyeh Island, Tsinghai Bay and Kiaochow Bay are all good places for fisheries and for animal collection. The coasts along Kiangsu are straight and sandy, and the only good fisheries are Tungsilientao outside of Lienyun Harbor and Chungming Island in the mouth of Yangtze River. For zoological studies, Tsintaoin is the best place in the southern part and Weihaiwei in the northern part.

(3) Tunghai region: From the estuary of Yangtze River southward to Chenhaikiao south of Amoy, with an area of 136,970 square knots. Many bays and islands are situated along its coasts. There are the inflows of the Rivers of Yangtze, Tsientang, Now and Min, and it is not only a pathway for warm currents, but also is influenced by cold currents. The bottom is mostly sandy or muddy and has plenty of nutrients. The depth is greater than that of Hwanghai, and the average temperature is about 20° C. It has by nature the most

favorable conditions and is the best place to study marine zoology. The estuary of Tsientang River in Hangchow Bay of Chekiang opens widely outward like a funnel. At every spring tide the sea water enters far up the river and forms the well-known "Tide of Tsientang"; thus it is an excellent area for studying the tides. Chowshan Island, outside the bay, contains plenty of aquatic life and is crowded with fishing boats. Tinghai, a large island in the southwest part, is a most suitable place for zoological studies in northern Tunghai and the Chekiang Provincial Fisheries Experiment Station is there. South of Tinghai, Haianshan Harbor and Sanmun Bay are likewise suitable places. More to the south, Taichow Bay and Wenchow Bay are furnished with both sandy and rocky shores, and should not be wanting in marine life.

The Kukien coasts, facing Formosa Strait, are as irregular as those of Chekiang. Besides the numerous bays and islands the slope of the bottom is more steep, the current is more rapid, and many reefs are scattered about. Funing Bay and Sansha Bay in the northern part, the estuary of Minkiang, Haitan Strait, Hsinghwa Bay and Meichow Bay in the middle part, all have good fisheries and are suitable for zoological studies. But the best place for studying marine zoology in the southern part of Tunghai is the Bay of Kinmen and Amoy where Weitou Cape is situated to the north of it, Chenhai Cape to the south and the two islands of Amoy and Kinmen in the middle. In addition to the geological advantages, Amoy is the most important, due to its having the University of Amoy, and being the original place of the Marine Biological Association of China.

(4) Nanhai region: From the south end of Formosa Strait through the coasts of Kwangtung to the Gulf of Tongking, west to Hainan Strait, has an area of 126,672 square knots. The depth of water near the coasts is not over 15 fathoms, the greater the distance from the coasts the greater the depth, its average being greater than that

of Pohai and Hwanghai. Generally, it is a plain area, though there are some reefs near the coasts. Due to its nearness to the equator and the influences of seasonal wind and hot currents, its temperature is higher than the other three. The average temperature is above 22° C. and it is well distributed with tropical oceanic organisms. Its irregular coasts give many bays, of which the famous ones are Tuolin Bay, Swatow, Kieshi Bay, Mirs Bay, Bias Bay, Estuary of Conton River, Tin Pak, Gulf of Kwangchow and the Gulf of Tongking. Also there are many scattered islands, Tungsha Islands (Pratas) and Shisha Island (Paracel Islands and reefs) are the far ones; the near ones are Namoa Island, Tahoa Island, Hongkong, Wanshan Island, Changchwen Island, Haichwen Island, Hailing Island, Tunghai Island, Kweichow Island and Hainan Island, all of which contain an abundance of sea life. Hainan is one of the largest islands and is the southernmost place in China; thus it is the best place for studying tropical animals. In 1933 there was a Hainan Island Biological Expedition, which was the first organized collection there.

First Period (Before 1800)

The marine animals were observed and recorded by our scholars very early, but most were from the standpoint of economy, without the objective of pursuing truth. In spite of their incorrectness, such books contain much valuable knowledge, especially the "Hai Wei Seh Jen," "Hai Tseo Yu Lu," etc., giving many detailed statements on the habits and ecology of marine animals. Other books, as "Erh Ya Sheh Wen," "Ku Chin Chu," "Min Shu," "Chung Kwui Lu," "Erh Ya Yi," "Tsi Min Yao Shu," "Chih Sheng Chih Shu," "Pen Zao Kang Mu," "Kwei Hai Chung Yu Chih," have also many records on marine animals; of which "Pen Tsao Kang Mu" gives the medicinal value in detail, and "Tsi Yao Shu" and "Chung Kwui Lu" give their cookery. The name used in the

ancient books, as "Wen Na Show" (*Otaria ursina*), "Fan Cheh Yü" (*Mola mola*), "Chu Sheng" (*Solen*), "Kwui Ko" (*Arca*), etc., are still used in modern zoology. There were quite a few marine animals mentioned in literature, for example: "Tan Kan Tieh" of "Wang Yi Chih" in Tsing Dynasty, "Shui Tzu Kia Nen Po" of "Mao Sheng," "Shih Hao Shih" of "Mei Yao Chen" in Sung Dynasty, "Hai Che Chih" of "Sheh Tsung Ko" in Yuan Dynasty, "Shen Tzan" and "Kan Tze Sung" of "Chang Lu Lan" in Ming Dynasty, and many verses about them in the famous "Hai Wei Seh Jen." These literary verses stated the morphology and habitats of marine animals, sometimes very correctly, as the king-crab in "Shui Tzu Kia Nen Po" was named "Lord long tail," which is correct.

In the early age of the Tsing Dynasty, "Ku Ching Tu Shu Tsih Cheng" was completed by Tsiang Ting Si. This book contains a part of "Peh Wu Hwei Pien" which deals with marine animals very thoroughly. Since then no great work has been written; the suggested reason is the lack of scientific studies.

Second Period (1800–1929)

In the nineteenth century our world communications were well developed. In order to obtain safety in navigation, not only had the character of ocean been extensively investigated and studied, but at the same time the marine life had also been collected, either for scientific ends or for practical aims, and a great quantity of work on animals of the deep or remote waters had been done.

The English ships *H. M. S. Samarang* (1843–46), *H. M. S. Sulphur* (1844–45), *Lightening* (1863) and *Porcupine* (1869–70) had made oceanic explorations, but the most famous one is Challenger's expedition (1873–76). The material obtained has been studied by different authorities and published in more than fifty great volumes. Therefore a great deal of work was done by

other nations. The well-known ones are Gazell (1874–76), National (1889), Valdivia (1898–99), Gaues (1901–03) and Planet (1906) of Germany; Blake (1877–80) and Albatross (1877–1900) of U. S. A.; Voringen (1875–78) of Norway; Vega (1878–80) and Antarctic (1901–03) of Sweden; Travailleur et Talisman (1880–83), Gaudan (1895), Francais (1903–05) and Pour quoi pas (1908–25) of France; Vitiaz (1886–89) of Russia; Washington (1881–82) and Vettor Pisani (1882–85) of Italy; Belgica (1895–99) of Belgium; Ingolf (1895–96) of Denmark; Siboga (1899–1900) of Holland; and Hirondelle (1885–88) and Princesse-Allice I et II (1891–1907) of Monaco. These contributed much to oceanography, marine biology and marine physics. Recently, in order to make thorough studies, numerous marine biological stations have been established on the sea coasts, such as Woods Hole in U. S. A., Plymouth in England, Rosscoff in France, Naples in Italy, etc.

The fishery as a practical branch of marine biology was also well developed during this period. The International Association of Oceanography (1901) was organized by the states of the North Sea, and then followed by the Mediterranean states. In China there were no far sea explorations nor marine biological stations until the early years of the Republic of China; since then some fisheries schools and experimental stations have been established; they emphasized the introduction of western methods but neglected research work; thus the study of marine zoology was only taken up occasionally by a few foreign zoologists and their works are confined to the fishes of interest to them, and are often mixed with non-marine forms. There are only a few which deal with the animals other than fishes and limited to those easy to collect and preserve. At the end of this period, the Chinese students in Europe and America began to publish papers in foreign journals and moreover to organize science societies, and to participate in international

science organizations. The Science Society of China was established in America in 1914, and the Biological Science Society of China was organized in France in 1924. The author has participated in the International Congress of Oceanography held in Sevilla, Spain, in 1929, as a delegate of science organizations, and published a paper ("Action de l'eau de mer diluée sur le développement des gastropodes Opisthobranches," *Congr. inter. de Oceanografia T. I.*, p. 253).

There were about fifty foreign scholars during this period working on fishes and about ninety papers were written by them. The most important ones were: Basilewsky, Stephanus, 1885, giving seven species of Chinese marine fishes; Bleeker, Pieter, 1857, one species, 1863, three species, 1864, seven species, 1872, five hundred and seventy species in his "Mémoire sur la fauna ichthyologique de Chine," 1872, nineteen species in his "Addition au mémoire sur la fauna ichthyologique de Chine," 1873, one species, 1874, three species, 1897, two species, 1879, twenty-one species; Boulenger, George Albert, 1895, twenty-five species; Canton, T. C., 1842, seven species; Courtois, F., 1917, one species; Cuvier, G., et Valencienne, A., 1828–48, three species of Chinese marine fishes in the great work on "Histoire naturelles des poissons" of 22 volumes; Day, Francis, 1878–88, seventy-four species; Dumeril, August, 1865–70, seven species; Everman, B. W., and Shaw, T. H., 1927, twenty-three species of marine fishes in the "Fishes from Eastern China with descriptions of new species"; Garman, Samuel, 1913, thirteen species; Gray, J. E., 1831, three species, 1830–37, two species, 1834, one species, 1851, one species; Guichennot, Alphonse, 1869, one species; Gunther, Albert, 1859–70, one hundred and sixty-five species of Chinese marine fishes in his 8 volumes of "Catalogue of the fishes of the British Museum," 1873, nine species of Chefoo fishes, 1873, twenty-five species in "Report on a collection of fishes from China," 1874, thirty-seven species, in his

"Third notice of a collection of fishes made by Mr. Swinhoe in China," 1880, five species in Challenger's Report, 1898, thirteen species in his "Report on a collection of fishes from Newchwang, North China"; Jordan, D. S., and Fowler, H. W., 1902, one species, 1903, two species; Jordan, D. S., and Herre, A. C., 1906, one species, 1907, one species; Jordan, D. S., and Hubbs, C. L., 1925, seven species; Jordan, D. S., and Richardson, R. E., 1908, six species, 1910, seven species; Jordan, D. S., and Seale, A., 1905, sixty-seven species in "List of fishes collected in 1882–83 by Pierre Louis Jouy at Shanghai and Hongkong," 1906, three species; Jordan, D. S., and Starks, E. C., 1906, thirty-one species; Jordan, D. S., Tanaka, S., and Snyder, J. O., 1913, twenty-three species; Jouan, Henri, 1867, forty-five species; Karoli, Janos, 1882, seven species; Kaup, Jahann Jabob, 1859, one species, 1860, one species; Kishinouye, Kamakichi, 1907, one species, 1923, five species; Kner, Rudolf, 1865–67, forty-one species, 1875, one species; Lacépéde, B. G. E. de, 1798–1803, five species in his five volumes of "Histoire des Poissons"; Martens, Edward Von, 1865, one species, 1875, seventy-one species, 1876, one species; McClelland, John, 1844, nine species in his description of a collection of fishes made at Chusan and Mingpo in China by G. R. Playfair; Morrison, W., 1898, four marine fishes of North China; Müller, J., and Henle, J., 1841, two species, 1844, one species; Norman, J. R., 1925, two marine forms in his "Two new fishes from China"; Osbeck, Peter, 1751, nine species, 1757, one species, 1765, one species, 1771, three species of Chinese marine fishes; Oshima, Masamitsu, 1926, twenty-six marine fishes in his "Notes on a collection of fishes from Hainan obtained by Professor S. F. Light"; Peter, W. C. H., 1880, sixty-one species of Mingpo marine fishes, 1880, three species of Hongkong; Reeves, C. D., 1927, eleven marine forms of northeastern China and Korea; Regan, C. T., 1905, one species, 1908, five species of dogfishes; Rendahl, H., 1919, three species,

1923, one species, 1924, twenty-eight species; Richardson, Sir John, 1844–45, eleven species in *H. M. S. Sulphur's* voyage, 1846, three hundred and twenty-six species in "Report on the ichthyology of the sea of China and Japan," 1848, fifteen species in *H. M. S. Sawarang's* voyage during 1843–46; Rutter Cloudsley, M., 1897, published hundred and five species of Swatow fishes; Souvage, Henri Emile, 1874, one species, 1881, thirty-eight species in "Sur une collection de poisson de Swatow"; Seale, Alvin, 1914, hundred and twenty-three species in "Fishes of Hongkong"; Smith, Hugh McCormick, 1913, three species of dogfishes from China sea; Steindachner, Franz, 1866, two species, 1867, twenty species, 1870, one species, 1892, seven species, 1893, seven species; Steindachner, F., and Doderlein, 1883–87, four species; Temminck and Schlegel, H., 1843, one species; Vahl, Marten, 1897, one species; Van Dam, Anna J., 1926, one species.

The above scholars who did the greatest work of Chinese marine fishes are: Bleeker of Holland, Günther and Richardson of England, Jordan, Rutter and Seale of America.

In addition to fishes, the study of Mollusca in this period must be considered. Adams, A., 1861–64, published three papers on Mollusca of the seas of North China and Japan (*Ann. Mag. Nat. Hist.*); Annandale, T. N., and Prahad, B., 1923, had a report of Mollusca of Chekiang, including several species of Bivalves and Gastropods; Bergh, R., 1870–1908, published six volumes of "Malacologische Untersuchungen im Archipel der Philippinen" which contained some Chinese marine Gastropods. And there are Chinese marine mollusca forms also in the works of Dunker, W. (*Ind. Moll. Mar. Jap.*); Fisher, P. (*Man. Conchy.*), Lischke, C. F. (*Jap. Meer. Conchy.*), Martini and Chemnitz (*Syst. Conchy. Cab.*), Pilsbry, H. A., and Tryon, G. W. (*Man. Conchy.*), Pilsbry (*Cat. Mar. Moll. Jap.*), and Sowerby, G. B. (*Thes. Conchy.*). Scholars who studied Chinese Echinoderms are Fisher, W. K., 1922; Smith, G. A., 1927, etc.

The materials, the foreign scholars studied, were mostly collected by seamen, merchants and missionaries; only Grabau, A. W., of Peking University, and Light, S. F., of the University of Amoy, worked along the Chinese coasts.

Grabau, in addition to lecturing, worked on geology and some works on zoology which influenced very much the development of paleontology and marine zoology. His most important work is "Shells of Peitaiho" which is published with S. G. King in 1928 (The Peking Society of Natural History), and deals with 127 species: 60 bivalves, including 12 new species, 8 new varieties, 67 gastropods, including 16 new species and 7 new varieties.

Light, S. F., made a zoological collection of Hainan Island in 1922 for the University of Amoy, in which 26 species of marine fishes were collected. His two works on Amphioxus (1923), "Amphioxus Fisheries near the University of Amoy" (*Science,* Vol. LVIII, pp. 57–61) and "The Biological Importance of Amphioxus" (*China Jour. Sci. Arts,* Vol. I, pp. 346–359) are often quoted by the zoologists of different countries.

Arthur de Carle Sowerby (1922–30) dealt with Tunicata, Echinodermata, Coelenterata and marine Crustacea in volumes IV and V of "The Naturists in Machuria" and the most abundant forms were marine fishes (266 species); his other book, "A Naturist's note-book in China," 1925, also deals with some marine representatives of each phylum along the Chinese coasts.

The biological institutes founded by foreigners as "Musée Huang Ho Pai Ho" in Tientsin, "Heude Museum" in Shanghai and other organizations have no great offerings in this line.

Third Period (1929 to Wartime)

Owing to the increasing number of biology students, either training in our Chinese colleges or oversea, and the returning of biological associations established in Europe and America; this period, from 1929 to the Sino-

Japanese war, is the period in which our own zoologists began to work. The following is a brief account of the bodies which work on the marine zoology.

1. Academia Sinica was founded in 1928, including an Institute of Biology which greatly emphasized marine zoology. According to the resolution of the China branch of the Section of Oceanography, Pacific Science Association, held on the 10th of April, 1935, this institute was made responsible to establish an institute of marine biology in Tinghai. The same year they made an investigation of fishes in Pohai Gulf. From 1931 they began to publish "Sinensia, contributions from the National Research Institute of Biology, Academia Sinica." They have papers on marine zoology of fishes (H. W. Wu, P. W. Fang), marine leeches (H. W. Wu), protozoa (C. C. Wang, Dashu Nie) and oceanographical investigations of Pohai and Shantung Peninsula (H. W. Hu, S. F. Tang).

2. National Academy of Peiping, was prepared in 1928 and established in September, 1929, including institutes of zoology, botany and physiology of which the Institute of Zoology works on marine zoology. They had collected over 10,000 specimens of marine animals at the main points of the China coasts such as Peitai Ho, Chefoo, Wei Hai Wei, Cheng Shan Tou, Tsingtao, Amoy, Hongkong and Batavia (Java). They established Chefoo Laboratory of Marine Zoology in 1932 and enlarged it into the Biological Laboratory of Pohai in July of 1935. They organized the Zoological Expedition of Kiaochow Bay with Tsingtao Government in the spring of 1935 to study the marine animals and also carry on the oceanographical investigations. In 1937 an Institute of Biological Oceanography and an Aquarium were established in Wei Hai Wei. Their works are mostly on fishes (Koo Kwang Chung), Protochordata (Tchang Si and Koo Kwang Chung), Mollusca (Tchang Si, Siangli Ku), Echinodermata (F. Y. Chang), Brachyura (Yung Pin

Liu), Pycnogonida (T. H. Lou) and oceanographical problems of Kiaochow Bay and Chefoo Bay (Tchang Si, S. K. Chang, S. T. Ma). They have two kinds of publications: one is "Contributions from the Institute of Zoology, Academy of Peiping," written in English or French and with Chinese Summary; the other is called "Bulletin" written in Chinese and with English summary.

The Institute of Physiology has also some papers on marine zoology (Kin Lipin, Tchang Si, Tai Lee, Liu Yusu) in its publications.

3. The Biological Laboratory of the Science Society of China is the senior one, being established earlier than the others, and began to publish "Contributions from the Biology Laboratory of the Science Society of China" in 1925. Papers on marine animals mostly concern fishes (K. F. Wang, H. W. Wu, S. F. Tang), Nemathelminthes (H. W. Wu) and Protozoa (C. C. Wang, Dashu Nie).

4. Fan Memorial Institute of Biology: was founded in 1928. Its zoology division has made collections along the China Sea coasts, and participated in the Biological Expedition of Hainan Island. Papers are mostly on Crustacea (C. J. Shen, S. C. Yu), Mollusca (Chi Pin and Teng Chien Yan) and are published in "Bulletin of the Fan Memorial Institute of Biology" and "Zoologia Sinica."

5. Tsingtao Observatory: This institution added an oceanographical section in 1928. Its principal work is to investigate the temperature of sea water and character of tides and sea bottom of Kiaochow Bay. They published "The distribution of surface water temperature in the North Pacific ocean" in 1930 and at the same time offered a "Bulletin on oceanography of the Tsingtao Observatory," which is the first oceanographical journal in China.

6. Tsingtao Aquarium was founded in 1932, and cooperated with Tsingtao Observatory. Beside the cultivation of aquatic animals, several hundred kinds of specimens have been exhibited, which has helped very much to popularize the knowledge of marine biology.

7. Biological Laboratory of Pohai was first established in 1932 by the Institute of Zoology, National Academy of Peiping, under the name of "Chefoo Laboratory of Marine Zoology." Then because of war, it was discontinued. In January of 1933 it was reopened by Chefoo Museum and closed again in 1935 due to the removal of this museum. In the spring of 1935 it was reestablished by the Institute of Zoology, National Academy of Peiping, and its name was changed to the present one by resolution of China Branch of the section of Oceanography, Pacific Science Association. Its principal works are: (1) Measurement of the temperature of sea water of Chefoo Bay under the depth of 3 feet, 15 feet and 25 feet. And investigations of bottom characters. (2) Collection of marine plankton. (3) Investigation of fishes' migrations. (4) Collection of marine animals of Chefoo Island, Kwangtung Island, Yangma Island and the neighboring coasts. Two volumes of reports (S. K. Chang, 1936–37) have been published, each dealing with the works of a year.

8. Tsingtao Institute of Marine Biology: The building was completed on December 25, 1936, and was closed due to the Sino-Japanese war.

9. Chekiang Provincial Fisheries Experiment Station, established in February of 1935 at Ting Hai. There were two kinds of publications, one was the extension series, using popular language and designed to promote the livelihood of fishermen, and to introduce new fishing methods. The other was "Bulletin of Chekiang Provincial Fisheries Experiment Station," to publish their researches (Fishes: S. Y. Lin, Chin Tse Yu, Cephalopoda: S. Y. Lin, T. P. Chen).

10. Marine Biological Association of China: established at Amoy in July of 1930 by the China Foundation for the Promotion of Education and Culture and the University of Amoy for the purpose of promoting and popularizing the knowledge of marine biology. The financial source of this association was the China Foundation and

Rockefeller Foundation. The University of Amoy contributed its share in providing for laboratory and library facilities, housing accommodations and the valuable service of its staff. Every year they invited the different biological institutions to hold a meeting, first meeting in 1931, second in 1932, third in 1933. Three volumes of reports (1932–34) were published containing eight papers on marine biology (Fishes: K. F. Wang, Amphioxus: Ernest Hartman, Mollusca: Tchang Si, T. C. Yen, Echinodermata: T. Y. Chen, Protozoa: C. C. Wang, Dashu Nie, etc.). It was combined with the Zoological Society of China in 1935.

11. The Zoological Society of China, established in 1934, next year gave *The Chinese Journal of Zoology* (Mollusca: Sohtsu G. King and Chi Pin, Crustacea: Chia Jui Shen, S. C. Yu).

12. China Branch of the Section of Oceanography, Pacific Science Association: It was produced by the resolution of the Society of Oceanography of Pacific Science Association in 1933. First meeting was held on April 10, 1935, at Academia Sinica, Nanking, and resolved its main works to be: (1) Survey of navigation lines; (2) investigations of Pohai fisheries; (3) investigation of coral reefs; (4) to establish four marine biological institutes, one in Amoy by the University of Amoy, one in Tinghai by the Academia Sinica, one in Tsingtao by the Zoological Society of China, Tsingtao Observatory and Shantung University, etc., one in Chefoo or Wei Hai Wei by the National Academy of Peiping. Another resolution was to divide its works into five groups: (1) Group of fishery technology; (2) Group of fisheries; (3) Group of coral reefs; (4) Group of oceanic physics and chemistry; (5) Group of marine biology.

13. Biological Expedition of Hainan Island (1932–33): It was organized by the Academia Sinica, Shantung University, Science Society of China, Fan Memorial Institute of Biology, etc. Papers upon the materials obtained

were contained in publications of the above corresponding organizations.

14. Zoological Expedition of Kiaochow Bay: It was organized by the National Academy of Peiping and the Tsingtao Government. Four collections of oceanographical investigations were done during the following periods, in 460 working stations: first period, from May 1st to June 5th, 1935; second, October 2nd to November 1st the same year; third, April 23rd to May 25th, 1936; fourth, September 10th to October 6th, the same year. A total of four hundred specimens was collected. Beside attention was paid to the distribution of marine animals, economic investigation of fishes and Mollusca, the most important result was the discovery of Tsingtao Amphioxus (*Branchiostoma belcheri tsingtauensis*) and Enteropneusta (*Dolichoglossus* and *Balanoglossus*). The former was first found in the coast of North China and the latter was first recorded in China.

Due to the geological conveniences, the University of Amoy in Amoy and the Shantung University in Tsingtao each established a research laboratory of marine biology and ecology. The habits and embryology of marine animals were their studying subjects.

The results of studying marine zoology have also often appeared in the publications of other Chinese universities or societies, such as *Lingnan Science Journal, Hongkong Naturalist, Science Report of the National Tsing Hua University, The Science Quarterly of the National University of Peking, Bulletin de la Faculté des Sciences de l'Université Franco-Chinoise de Peiping* and *Peking Natural History Bulletin.*

Summary

The China coasts are about 400 miles long, extending from 41° to 19° North latitude, possessing the characters of temperate and torrid zones. Geographically they can be divided into four regions, namely, Pohai, Hwanghai, Tunghai and Nanhai.

Marine animals were recorded very early, even in the Chou Dynasty, and continued through the Dynasties of Han, Tang, Sung, Yuan, Ming and Tsing. Yet, due to the lack of scientific methods, there were no great contributions until 1800. In the second period (1800–1929) the foreign zoologists had occasionally done some work on Chinese marine animals, but only in small quantity and not systematical, of which the comparative complete work was the study of fishes.

In the third period (1929 to wartime) the Chinese research bodies were born and the number of biology students was increased, so that studies of marine zoology could be made by Chinese scholars. Their work emphasized taxonomy, because it is basic for other research and it is important for editing the Chinese fauna. Among the works on higher animals, those of fishes have occupied the greatest part and Protochordata next. On invertebrates, those of Crustacea and Mollusca have been comparatively numerous, those of Echinodermata, Annelida and Protozoa next, those of Platyhelminthes and Nemathelminthes have been rather few, and there have been no special papers on Porifera and Molluscoidea. Moreover, the physical and chemical characters of the three bays, namely, Chefoo, Kiaochow and Amoy, have been investigated, and general knowledge of fishing grounds and fishing periods of different regions are known.

During the war period from 1937 to 1945, the coastline of the Chinese territory was almost entirely occupied by the Japanese, therefore the studies of marine zoology necessarily ceased entirely.

THE EVIDENCE AGAINST POLYPLOIDY IN SEXUALLY-REPRODUCING ANIMALS

M. J. D. WHITE
UNIVERSITY COLLEGE, LONDON

In view of the enormous number of polyploid species and varieties which are now known in plants the hypothesis that something of the same kind may have occurred, although less frequently, in the evolution of the Metazoa is an attractive one. Many cytologists have, in fact, reported cases which appear to support such a view. In various parthenogenetic species of animals at any rate (Artemia and Trichoniscus among the Crustacea, Otiorrhynchus and related genera in the Coleoptera, Solenobia in the Lepidoptera and Saga in the Orthoptera) polyploid forms are known with certainty. In sexually-reproducing animals, on the other hand, the evidence which has been put forward is of a very equivocal kind and has recently been criticized (White, 1945, Ch. 8). The purpose of this note is to discuss some recent claims of the same nature which have appeared since the publication of the above-mentioned review or which were unknown to me at that time, owing to the impossibility of obtaining German periodicals.

Sexually-reproducing species may, for the present purpose, be divided into those that are hermaphroditic and those which are bisexual. Actually, any two of the three great categories of reproductive mechanism (parthenogenesis, bisexuality, hermaphroditism) may be combined in species with an alternation of generations, but such cases will not be considered here. A further distinction in regard to the reproductive mechanism may be drawn between those hermaphroditic species in which self-fertilization is possible and those in which it is not (too few data, unfortunately, exist on this point).

It was long ago pointed out by Muller (1925) that the existence of a sex-chromosome mechanism must consti-

tute a barrier to the establishment of polyploidy, since the heterogametic (XY) sex will become XXYY and will hence produce mostly XY gametes (i.e., it will become effectively homogametic). This argument seems to hold good in those organisms whose sex-determining mechanism is of the Drosophila-type, depending on a "balance" between X-chromosomes and autosomes. It can hardly apply, however, in those cases where sex depends on the presence or absence of a Y. Such a situation exists in the plant Melandrium (Westergaard, 1940, Warmke and Blakeslee, 1939) where artificially-produced tetraploid strains having the constitution XXXX(♀) and XXXY(♂) are bisexual and fertile.[1] In animals very few cases are known in which sex depends on the presence or absence of a Y, but such a situation exists in the Axolotl (Humphrey, 1945) and may, of course, be widespread, especially in groups where no cytologically distinguishable sex chromosomes exist (Fishes, Amphibia, some Nematocerous Diptera). In these cases "Muller's principle" would not prevent the evolution of polyploidy.

In any event, Muller's principle would not act as a barrier to the formation of polyploid varieties or species in hermaphroditic animals, so that in the Platyhelminthes, Oligochaeta, Hirudinea and Pulmonata one might expect to find polyploid forms. The evidence, however, is mostly negative (White, 1940, 1945). In the Turbellaria there are a few species which might be regarded as possible tetraploids, but no case is absolutely clear, although in the genus Phaenocora there are species with three chromosomes and others with six that may be tetraploids.

In the Cestodes the cytological work of Jones (1945), who found that the chromosome numbers of fifteen species ranged from 5 to 8, provides no evidence for the existence of polyploidy.

We may now turn to two recent papers whose authors claim to have discovered polyploid species in exclusively bisexual groups. In the butterflies Lorković (1941)

[1] Löve (1942) has recorded tetraploid Melandrium in the wild.

established the chromosome numbers of 85 species. Most of these numbers are between 29 and 31, but in the family Lycaenidae haploid numbers of 23 or 24 occur in a large number of species.

There are three genera in which Lorković found species with unusually high chromosome numbers which he interprets as polyploid. In Leptidea (Pieridae, subfamily Dismorphiinae) he studied *L. sinapis* L., *L. morsei* Fent. and *L. duponcheli* Stgr. The first of these shows an extraordinary variability in chromosome number, the number of bodies (univalents, bivalents or multivalents) present at first metaphase ranging from 26 to 41. In view of the impossibility of distinguishing bivalents from univalents and multivalents it is clear that a study of the first meiotic division alone does not provide much information as to the real nature of the chromosomal variation in *L. sinapis;* only a study of the gonial or somatic divisions would enable a proper analysis to be made.

In *L. morsei* Lorković found 54 (occasionally 53) bodies at first metaphase. Here again, there seems to be some variability in chromosome number, although not to the same extent as in *sinapis*. Lastly, in *L. duponcheli* the haploid number was 104.

Lorković argues that *morsei* is a tetraploid species, *duponcheli* an octoploid one. But in reality there is no need to assume this. The literature on chromosome numbers in Lepidoptera and Trichoptera is full of instances where closely related species, placed by taxonomists in the same genus or subgenus, have very different chromosome numbers (see White, 1945, Table 8, for some examples). Where only a few species have been studied it may happen that one has a chromosome number approximately double that of a related one, but when all the forms of the group have been studied cytologically it usually happens that a graded series of numbers is found (*e.g.*, in the Trichopteran genus Limnophilus and in the Lepidopteran genus Orgyia). In the case of Leptidea it

is impossible, on the existing evidence, to say what the fundamental or "typical" chromosome number of *L. sinapis* is. Federley (1938) found 26 bodies at first metaphase in Finnish material, Lorković 28–39 in eleven Dalmatian individuals, 41 in two from Fontainebleau; it is thus possible that certain populations have constant chromosome numbers, others fluctuating numbers. In any case the variability is almost certainly due to the occurrence of "fragmentation" or "fusion," a single chromosome in one individual being represented by two or more elements in another—but whatever its precise nature it is probable that the higher chromosome numbers of *morsei* and *duponcheli* have arisen in the course of evolution by the same process as has given rise to the intraspecific chromosomal variation shown by *L. sinapis*. Lorković's hypothesis is considerably more complicated than this, however. He is impressed by the fact that *sinapis* is morphologically intermediate between *morsei* and *duponcheli* and he consequently believes that both *morsei* and *sinapis* are tetraploids, but that the latter has undergone a subsequent reduction in chromosome number through "fusions." This, surely, is an unnecessary complication of the issues. The fact that *sinapis* is structurally intermediate between the other two species probably merely indicates that it is nearer to the ancestral form from which the other two were derived. More work should obviously be carried out on the cytology of this genus (an investigation of the Chinese *L. gigantea* and of the Irish subspecies of *sinapis*, which is said to resemble *duponcheli*, would be of value) but we do not believe that any evidence of polyploidy would emerge from such a study. One reason for not regarding *duponcheli* as an octoploid (as Lorković does) is the fact that it has one bivalent which is considerably larger than any of the others (and not four large ones, as we should expect in an octoploid).

Another butterfly genus in which Lorković believes polyploidy to have occurred is Erebia, the known chromosome numbers of the species being tabulated below:

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	Haploid number	
E. medusa	11	Federley, 1938; Lorković, 1941.
E. oëme	14	Lorković, 1941.
E. epiphron cassiope	17	" "
E. pharte, glacialis and *pronoë*	19	" "
E. melas, gorge and *aethiops*	21	" "
E. nerine	22	" "
E. lappona	28	Federley, 1938.
E. ligea and *disa*	29	" "
E. ottomana	40	Lorković, 1941.

Here we have a good example of a graded series of chromosome numbers, the lower ones having probably been derived by repeated "fusions" of originally separate elements, the higher ones by "fragmentations" (owing to the impossibility of detecting any centromeres in Lepidopterous chromosomes one can not distinguish between acrocentric and metacentric elements and the precise nature of the structural changes involved in "fusions" and "fragmentations" must remain undefined for the present). Lorković does not go to the length of supposing *nerine* to be a tetraploid of *medusa* (presumably because he is reluctant to consider so low a number as 11 as a primitive one), but he does consider *ottomana* to be a tetraploid (this in spite of the fact that it has a single very large bivalent at meiosis and that no Erebia species with 20 chromosomes is known). The case for *ottomana* being a tetraploid is, of course, weakened by the existence of several species of the genus with 28 or 29 chromosomes.

A third case in which Lorković assumes polyploidy is in the "Blues" (genus Polyommatus or Lycaena). Here three species are known to have 23 chromosomes and nine have 24, while *P. bellargus* has 45 and *P. coridon* has 90. Here both *bellargus* and *coridon* have single large chromosomes, which would seem to argue against their being polyploids. These two species are closely related and are often put in a separate genus, Lysandra. A rare form named *P.* (*L.*) *polonus* Zell. is probably the natural hybrid between them (Ford, 1945). The reasonable view

would seem to be that Lysandra is a group of forms in which the basic chromosome set of the Lycaenidae (23 or 24 elements) has been repeatedly broken up into smaller elements.

It may be worth while to speculate as to why several of the species of Lepidoptera with unusually high chromosome numbers (*L. duponcheli, E. ottomana, Polyommatus bellargus* and *coridon*) have one element which is much larger than any of the others. We would tentatively suggest that this is the X-chromosome which has not undergone fragmentation in the course of evolution, its "conservatism" in this respect being caused by the fact that any fragmentation of an element carrying sex-genes distributed along its length would give rise to a complex sex-determining mechanism which would almost certainly be inefficient in various ways.

Another author who has claimed to have found evidence of polyploidy in a group of exclusively bisexual animals is Svärdson (1945) who worked on the Salmonid fishes. His results are tabulated below:

	Haploid number
Osmerus eperlanus (Smelt)	29
Salmo salar (Salmon)	30
S. trutta (Brown Trout)	40
S. alpinus (Char)	40
S. fontinalis (Speckled Trout)	42
Coregonus lavaretus (Gwyniad)	40
C. albula (Small Gwyniad)	40
Thymallus thymallus (Grayling)	51

It will be noted that not one of these numbers is a multiple of any other. In order to justify his view that polyploidy has occurred in these teleost fishes Svärdson is forced to assume that they have a "basic" haploid number of ten. On this view the Salmon would be a hexaploid, the Trout, Char, Gwyniad and Small Gwyniad octoploids and the Grayling a decaploid with two extra chromosomes. It must be obvious that this case is extremely weak. No members of the Salmonidae are known with haploid numbers of ten or twenty, and most

teleosts have quite high chromosome numbers, as is shown by the following examples (full details in Oguma and Makino, 1937):

	Haploid number
Onchorhynchus keta	37
Cyprinus carpio	52
Carassius carassius	47
Misgurnus anguillicaudatus	26
Oryzias (Aplocheilus) latipes	24
Lebistes reticulatus	23
Xiphophorus (several species)	24
Platypoecilus (three species)	24
P. variatus	25
Pungitius (two species)	21
Betta splendens	21
Hexagrammos octogrammus	24
Pholis pictus	23

It is obvious that these numbers provide no support for the theory of a basic number of ten, the only Salmonid other than those investigated by Svärdson (*Onchorhynchus keta*) having a haploid number of 37.

Lastly, we may mention two species in which we have ourselves postulated a tetraploid condition. We believe that these cases constitute genuine exceptions to the general rule that polyploidy has not occurred in the bisexual groups of animals. The first is the Sawfly Diprion simile, studied by Smith (1941). Here the females have 28 chromosomes in the oogonia, the males 14 in the spermatogonia (whereas related species have 14 in the female and 7 in the male). This seems a fairly clear instance of a tetraploid : diploid species in a group most of the members of which are diploid : haploid. But since these Sawflies are facultatively parthenogenetic it is not entirely unexpected and is perhaps more analogous to the undoubted instances of polyploidy in exclusively parthenogenetic animals, although the mechanism of sex-determination in Diprion simile still remains a puzzle.

Finally there is the case of the scale insect *Gossyparia spuria*, whose cytology was studied by Schrader (1929). This insect shows a very anomalous type of spermato-

genesis: there seem to be four chromosome sets, two of which are heteropycnotic and seem to undergo pairing in the prophase of meiosis, while the other two sets do not. This is clearly a peculiar case, and one would need to investigate related species before being sure that it was an instance of tetraploidy. The polyploidy of the germ-line in the Cecidomyidae (where the soma is diploid or haploid) also clearly represents a special case of a very anomalous type (White, 1946).

To sum up, one can say that, apart from species with obligatory or facultative parthenogenesis, the highly anomalous case of the Cecidomyidae and a somewhat doubtful instance in the Coccidae, the evidence for polyploidy in the bisexual species of animals is so equivocal that it must seriously be doubted if any such polyploid species exist. Even in the hermaphrodite groups polyploidy seems to be extraordinarily rare (far more so than in most groups of higher plants). This is possibly due to the rarity of self-fertilization in animals (a single tetraploid individual mating with a diploid would produce only triploid offspring which would be sterile on account of irregular meiosis). Apart from this there is the possibility that the nuclear : cytoplasmic volume relationships have a smaller degree of tolerance in animals than in plants.

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EFFECT OF THE SHORT EAR GENE ON NUMBER OF RIBS AND PRESACRAL VERTEBRAE IN THE HOUSE MOUSE[1]

DR. EARL L. GREEN AND DR. MARGARET C. GREEN

THE OHIO STATE UNIVERSITY

MANY effects have been attributed to the short ear gene (*se*—autosomal recessive) in the house mouse, *Mus musculus*. In addition to the decrease in size of ears (Lynch, 1921) for which the factor is named, there is evidence that it is associated with alterations in the shape of the skull, a muscular waviness of the tail (Snell, 1931), reduction in number of ribs (Snell, 1935), decrease in body size (Castle *et al.*, 1936; Law, 1938), and a malformation of the xiphisternum (Green and McNutt, 1941). This multiplicity of effects in different parts of the body, none of which are severe enough to reduce viability greatly, makes this character an ideal one for the study of gene action in development.

Eventually the problem will be to decide between two sets of alternatives. First, does the gene act at a single time or at different times during development? Second, does it effect a single process of development or several different processes?

Three steps are necessary in an investigation to answer these questions. These are (1) the establishment of inbred strains of mice in which one half of the animals are heterozygous for short ear (*Sese*), the other half are homozygous for short ear (*sese*), and all animals are homozygous for all other genes; (2) a thorough anatomical and physiological survey of these strains to determine what characteristics are affected by *se;* (3) a study of the development of these characteristics to determine

[1] The authors are deeply indebted to the Medical and Surgical Memorial Hospital of San Antonio, Texas, for facilities for maintaining mice during the period of the war and especially to the Director of the Pathology Laboratory, Dr. H. J. Schattenberg, without whose kindly assistance and interest this study would have been impossible.

whether or not they possess underlying similarities. This paper is concerned with the first step and with part of the second.

The establishment of inbred strains is necessary so that the differences between *Sese* and *sese* may be detected without contamination by other heterozygous gene pairs. This is especially necessary for quantitative characteristics, such as body size, on which many genes act, for in such cases the effects of the short ear gene can not be distinguished from the effects of other segregating genes. Obviously the establishment of inbred strains is not so necessary for characteristics which are sharply different from normal, such as the abnormality of the xiphisternum. For these, it is merely necessary to establish that such characteristics and short ears always appear together.

To accomplish the first step, a program was begun of inbreeding several strains of mice of known origin in which all matings were brother by sister and backcross in type, *Sese* $\times$ *sese*. This scheme of breeding with forced heterozygosis, according to the calculations of Bartlett and Haldane (1935), may be expected on the average to render all factors homozygous in ten generations of inbreeding except those in a space about equal to 7.5 per cent. of the total length of the chromosome on each side of the *se* locus.

Even with long-continued inbreeding this method gives homozygosis for all other genes only as a limit, and one can never be certain that a strain is completely homozygous for all such genes. It is the only method available for mammals, however, aside from that of discovering a new mutation in an inbred strain. The reservation must always be made that any observed difference in the two kinds of animals (*Sese* and *sese*) may be due to genes in the small portion of the chromosome which contains the known gene rather than to the known gene itself.

In this paper it will be shown that *se* causes a decrease in the number of pairs of ribs, but has no effect on the

number of presacral vertebrae. These are the first quantitative characteristics to be investigated in this study of the effects of the *se* gene.

Strains and Crosses

Four foundation strains, two homozygous for short ear (*sese*) and two homozygous for normal ear (*SeSe*), were used in the original matings to establish five heterozygous strains. The foundation strains with their vertebral types and the manner of origin of the derived strains are listed in Table 1. Of the derived strains, *aB*, *ab* and c^{ch} are now extinct.

TABLE 1

Origin of Foundation and Derived Strains, with Distribution in Percentages of the Skeletal Types of the Foundation Strains

Strain*	Origin	Number of mice	Ribs†			*psv*‡		
			12	13	14	25	26	27
Bagg	Jackson Lab.	3,022	...	18.7	81.3	...	73.9	26.1
C3H	Yale Univ.	200	...	100.0	...	96.5	3.5	...
P	Jackson Lab.	399	97.2	2.8	...	93.7	6.3	...
NB	Brown Univ.	321	...	100.0	...	0.6	99.4	...
aB	*P*(*C3H* × *P*)			(see Table 3)				
ab	*P*(*C3H* × *P*)			(see Table 3)				
c^{ch}	*NB*(Bagg × *NB*)			(see Table 3)				
C	(Bagg × *NB*)² Bagg			(see Table 3)				
Ab	(Bagg × *P*)²			(see Tables 2 and 3)				

* The Bagg and *C3H* strains have normal ears (*SeSe*), the *P* and *NB* strains have short ears (*sese*).

† Animals with any part of a thirteenth or fourteenth rib are classed as 13 or 14 respectively.

‡ *psv* = presacral vertebrae; animals with asymmetrical sacrums are classed with the higher number of presacral vertebrae.

The existence of heterozygous genes with visible effects closely linked to *se* would of course speed up the approach to homozygosis during inbreeding, since crossovers could be detected as soon as they appear and the appropriate chromosomes selected. Fortunately one such gene exists and was present in heterozygous condition in the early generations of all the derived strains. This gene is dilution (*d*), and it entered all crosses in the coupling phase (*DSe/dse*). It is linked to *se* by a map distance of 0.16, the closest linkage known in vertebrates (Grüneberg, 1943). A crossover between *d* and *se* would thus reduce the heterozygous length of chromosome on one side of *se* to less than 0.16 crossover units. Only a very large

number of generations of inbreeding without the use of *d* as a crossover indicator could produce an equal degree of homozygosis. Such a crossover (*dSe/dse*) occurred in the eighth generation of strain *Ab* and this strain is now homozygous for *d*. To date no crossover has occurred in strain *C*.

The number of pairs of ribs and the number of presacral vertebrae were recorded for mice of all five strains in the early generations of inbreeding, and of strain *Ab* in the twelfth and thirteenth generations. No data from recent generations of strain *C* are presented because this strain is not homozygous for *d*.

Animals were prepared for observation by a routine clearing and staining technic (Cumley, *et al.*, 1939).

Number of Pairs of Ribs

In strain *Ab* the number of pairs of ribs varies from 12 to 13. Thirteenth ribs occur in all degrees of development and are classified from 0 to 4 on each side, the maximum possible development being 8 for complete development on both sides. The distribution of rib grades in normal and short ear animals in the twelfth and thirteenth inbred generations is given in Table 2. Normal ear animals tend to have the thirteenth pair of ribs completely developed while short ear animals tend to have the thirteenth pair incompletely developed, the majority having no trace of a thirteenth rib. The difference is

TABLE 2

Distribution of Rib Grades in Normal and Short Ear Animals of the Twelfth and Thirteenth Generations of Strain *Ab*

Genotype	Sex	Pairs of ribs and rib grades									Total
		12	13								
			1	2	3	4	5	6	7	8	
dSe/dse	♂♂							1	4	64	69
	♀♀							1	1	83	85
	Tot.							2	5	147	154
dse/dse	♂♂	60	1	1	15	3	2	3	1	1	87
	♀♀	48	3	6	14	5	2	7	3	1	89
	Tot.	108	4	7	29	8	4	10	4	2	176

Se, normal ear; *se*, short ear; *d*, dilution.

almost great enough to be diagnostic for the two genotypes *Sese* and *sese*, although there is slight overlapping.

Evidence from the other four strains indicates that the effect of *se* is to cause a general decrease in the amount of rib tissue at the thoraco-lumbar border, rather than to determine the specific number 12. We may assume that differences in rib number associated with *Se* and *se* in early inbred generations are actually the effect of a length of chromosome no longer than that which remains heterozygous in the twelfth and thirteenth generations of strain *Ab*, since there is no diminution of the effect in the later inbred generations. Table 3 shows the

TABLE 3

EFFECT OF THE SHORT EAR GENE ON THE NUMBER OF PAIRS OF RIBS AND THE NUMBER OF PRESACRAL VERTEBRAE. GENERATIONS 1 TO 9 OF FIVE STRAINS

Strain	Sex	Ribs*						*psv*†						Total
		Dense, normal ear *DSe/dse*			Dilute, short ear *dse/dse*			Dense, normal ear *DSe/dse*			Dilute, short ear *dse/dse*			
		12	13	14	12	13	14	25	26	27	25	26	27	
aB	♂♂	3	89	1	67	7	..	78	15	..	64	10	..	167
	♀♀	2	83	..	73	10	..	66	19	..	55	28	..	168
	Tot.	5	172	1	140	17	..	144	34	..	119	38	..	335
ab	♂♂	1	46	..	42	11	..	22	25	..	26	27	..	100
	♀♀	..	45	..	43	9	..	25	20	..	26	26	..	97
	Tot.	1	91	..	85	20	..	47	45	..	52	53	..	197
cch	♂♂	..	46	33	1	65	..	..	78	1	1	65	..	145
	♀♀	..	31	32	..	68	..	..	60	3	..	66	2	131
	Tot.	..	77	65	1	133	..	..	138	4	1	131	2	276
C	♂♂	..	58	21	..	68	..	..	74	5	..	56	12	147
	♀♀	..	36	21	..	71	..	..	51	6	..	52	19	128
	Tot.	..	94	42	..	139	..	..	125	11	..	108	31	275
Ab	♂♂	..	79	..	19	34	..	4	75	..	3	50	..	132
	♀♀	..	63	..	18	36	..	2	61	..	2	50	2	117
	Tot.	..	142	..	37	70	..	6	136	..	5	100	2	249

* Animals with any part of a thirteenth or fourteenth rib are classed as 13 or 14 respectively.

† *psv* = presacral vertebrae; animals with asymmetrical sacrums are classed with the higher number of presacral vertebrae.

effect of *se* on rib number in the five strains up to the ninth generation of inbreeding. The general level of rib production varies among the different strains, but the short ear mice tend regularly to have one fewer pair of ribs than do the normal ear mice. Three strains (*aB*, *ab* and *Ab*) vary mostly between 12 and 13 pairs of ribs. In

two of these (*aB* and *ab*) nearly all normal ear animals have 13 pairs of ribs, and a large majority of short ear animals have 12 pairs of ribs. In the third (*Ab*) all the normal ear animals have 13 pairs of ribs and 35 per cent. of the short ear animals have 12 pairs of ribs. The remaining two strains (c^{ch} and *C*) vary mostly between 13 and 14 pairs of ribs. A large proportion of the normal ear animals have 14 pairs of ribs, while 100 per cent. of the short ear animals have 12 or 13 pairs of ribs. The gene *se* tends to inhibit rib production, but the specific number of ribs depends upon other factors in addition.

A difference in rib number associated with *se* was found by Snell (1935), but in his crosses *d* was also heterozyzous and his animals were not inbred.

Number of Presacral Vertebrae

Since some of the factors which determine the number of pairs of ribs may also affect the number of presacral vertebrae, the question arises whether *se* is such a factor or whether it acts upon the thoraco-lumbar border only. Table 3 shows the relationship of *se* to the number of presacral vertebrae in the five strains. In each strain there is some variability in the position of the sacrum. In three of the strains (*aB, ab* and *C*) this variability is considerable. The variability is not, however, associated with *se*. In four of the strains (*aB, ab,* c^{ch} and *Ab*) the percentages of mice with 26 presacral vertebrae are approximately the same in the *Sese* and *sese* groups (X^2 tests for association are all non-significant). In strain *C* there is an apparent tendency for short ear mice to have 27 presacral vertebrae more frequently than do normal ear mice. This association is not highly significant, however, when a test is made with the sexes separated. It seems most reasonable to conclude, therefore, that the short ear gene does not significantly affect the number of presacral vertebrae. Its action along the vertebral column is restricted to the thoraco-lumbar border.

No data are given for later generations of strain *Ab* because in this strain there is practically no variation

from 26 presacral vertebrae. It is unimportant in this case that only the early inbred generations are used, for if no difference between normal and short ear exists in them, a difference would not be expected to appear in later stages of inbreeding.

Conclusions

(1) For the purpose of studying the multiple effects of the short ear gene (*se*) in the mouse, five inbred strains with forced heterozygosis for normal and short ear (*Sese* × *sese*) were established and maintained by brother by sister matings. Two of the five strains have survived beyond the tenth generation of inbreeding, and one of these has the appropriate genetic constitution for detecting the effects of the short ear gene.

(2) In this one strain the short ear gene, or a small segment of the chromosome which contains it but no other recognizable genes, tends to reduce the number of pairs of ribs. This effect is confirmed by evidence from the early inbred generations of all five strains and is independent of the general level of rib production.

(3) The short ear gene has no effect on the number of presacral vertebrae.

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THE MAIN REGULARITIES IN THE FORMATION AND DEVELOPMENT OF THE ICHTHYOFAUNA OF RUNNING WATERS

G. NIKOLSKY
DEPARTMENT OF ICHTHYOLOGY, UNIVERSITY OF MOSCOW

INTRODUCTION

IT is well known that organisms inhabiting various biotops, among them a stream on the whole and its separate stations in particular, are most closely connected with environmental abiotic factors and with many other members of the community. It is quite obvious, therefore, that an alteration in some abiotic environmental factor or the appearance either of a new species in a certain community causes the latter to become modified in a definite way and adapted to new circumstances.

Changes in living conditions from the sources of the stream to its lower part take place in a definite manner, too; the same holds true with regard to the structure and behavior of water inhabitants, providing them with greatest steadiness in the struggle for existence. Moreover, since the river basin in the process of its development undergoes regular alterations passing gradually through developmental stages, we are justified to expect the stream ichthyofauna to change with alterations in biotops.

CHANGES IN ABIOTIC CONDITIONS

For a clear understanding of regularities determining the character and genesis of the river ichthyofauna the developmental process of a river basin is to be considered. The first phase of that process is usually associated with tectonic denivellations on the earth's surface. As a result of mountain formation there occurs, as a rule, a well-marked redistribution of water and first of all its excess at high altitudes. These excessive waters run down the natural slope in the form of flows into the lowlands, gradually working out their own beds.

Erosion in the mountainous part of the basin with sedimentation in its lower portion leads to the decline of the river becoming lesser and lesser. Simultaneously with a base-levelling and intensive erosion in the width of the river valley, a filling up of the latter with sediments takes place. This induces a greater meandering of the river, which in turn results in a decrease in its fall and rate of flow.

These erosive and accumulative activities, which often last for a very long time, serve to diminish the difference between watermarks at the source and mouth. Eventually a rapid river becomes transformed into a sluggish stream, differing but very slightly in its various parts.

The case just described may be regarded as an ideal one, whereas in nature the process of the river development is usually much more intricate. Due to various causes a super-position of several erosion cycles occurs, which produces a more complicated picture. Very frequently a gradual development of the river bed in the sense of a levelling down in the altitude marks of sources and mouth may be disturbed by new tectonic or epeirogenetic phenomena which lead to a new increase of erosive activities. Similar processes are seen to take place at present as well, exerting a definite action upon the ichthyofauna. Glaciation had also influenced rivers of North Europe and America, having destroyed old river valleys and greatly altered the earth's surface by an uneven accumulation of moraine materials, which caused great changes in drainage systems.

River basins may occasionally originate not only due to tectonic phenomena, but to modifications in the climate, increasing its moisture. In case of a basin arising under lowland conditions the first phase of its development is usually seen to fall out.

Most pronounced alterations are also seen to occur in the bottom deposits.

In the upper part of a mountain river in the zone of an intensive erosion its banks and bed are composed of rocks

from which pieces of various sizes are torn off and carried down the stream. Farther on there begins a noticeable accumulation of shingle and boulders deposited onto the river bottom and moving gradually with maximal flow down the stream, the erosion of banks composed of softer rocks taking place together with such an accumulation of large fractions. Towards the mouth smaller and smaller particles are accumulated; these pass first from a suspended state into that of driven sediments, being then precipitated on the bottom. Near the mouth a sedimentation of organic muds is seen to take place. With aging of the river the grounds of its upper parts become more and more reduced in area, while those of the lower part extend farther and farther up the current.

Such is the scheme of the morphological aspect of the process.

It would be safe to suppose that those alterations of the bed are connected with the most profound changes in hydrological conditions.

The first factor in determining the evolution of the river bed is the rate of flow. This factor conditions to a large extent the base-levelling, the distribution of bottom deposits and the type of rivers in general. The greatest declivity in the river which has built its profile of equilibrium falls on the uper part of the valley. There the flow-rate reaches its highest degree of velocity, performing alike its greatest mechanical work. In passing from the source to the mouth the rate of flow is slowing down, its rôle as a mechanical agent decreasing in importance. At the same time its significance in changing the salinity and gas contents of the water-body becomes more prominent. Moreover, the character of the river is closely connected with thermic conditions of its waters. In rivers fed from high altitudes due to the melting of glaciers and snow, the temperature of upper parts is usually lower than downstream, its range being much wider as well. In the distribution of temperatures great deviations from the typical one may be induced by the direction of the

river current, by the inflow of subterranean waters, etc. With the levelling of the source and mouth temperature, differences between the upper and lower parts may become lesser. The dissolved gas conditions are also dissimilar up and down stream. Thus in upper parts with the most rapid current where a complete mixing is produced, the water is found to be very rich in oxygen. In the middle part of the river the daily and seasonal changes in dissolved gas content may be observed. This dynamics is due to the processes of the destruction of the organic matter which go on in the middle and lower parts of the river. These processes produce alterations in other indices; thus the pH becomes more acidulous. In those rivers whose mouths are under the conditions of a hot climate the salinity of water in the lower parts greatly increases. Such are the mean regularities of the abiotic medium that determines the conditions of the river ichthyofauna's existence.

Regularities of the Fish Distribution in River Basins

Let us consider now the diverse actions of those factors on fishes, as well as their significance in the formation of fish populations in separate stretches of river beds. The principal factor, which either directly or through changes in other agencies determines the character of the ichthyofauna in various regions of the bed, is the rate of flow. First of all the latter factor acts as a mechanical agent in selecting a definite body form adjusted to existing conditions (Boyne, 1878; A. Nikolsky, 1891; Hora, 1930; G. Nikolsky, 1933, and others). Near the source where the current is very swift, only fishes adapted to resist the force of rushing waters may live. With the diminishing of the flow-rate towards the river mouth changes in the fish body form are noticed. In the upper parts of the river we find only fishes with a spindle-shaped body and a short and high caudal peduncle, *i.e.*, good swimmers as well as those with a depressed body and often with organs for attachment, *i.e.*, bottom dwellers.

The latter group of fishes live near the bottom among boulders and shingle where current is slow. As for bottom-living fishes a well-developed swim bladder is of no advantage to them and is, therefore, either little developed or even quite absent, its forepart being often inclosed in one bony capsule. In many bottom-living fishes of hillstreams the organs of attachment are represented by sucking disks which develop on the lower lip (Garra), on the thorax (Glyptothorax) due to changes pectoral (Homalopteridae) or ventral (Gobidae) fins (Hora, 1930). The body form of the fish is seen to change from the upper part of the stream towards its mouth with a decrease in the flow-rate, high-bodied species less adapted to the moving stream appearing gradually in the bed. A compressed body shape in those fishes is their adaptation to defend themselves against predators. The latter feed upon such fishes to a much lesser extent than upon spindle-shaped forms. Moreover, this specific high-body form facilitates rocking movements in a vertical plane, in securing food from the bottom (Vasnečov, in litt.). At the same time the percentage of bottom-living fishes somewhat diminishes, those with attachment organs completely disappearing on the muddy bottom. In approaching the lower parts of the river the spindle form of the body occurs almost exclusively in migratory species and predators. In those parts bottom-living fishes for which the bottom serves as a support (*e.g.*, loaches and the river-living Cottoid fishes) become very scarce, a fact which may be explained by the oxygen conditions of the deeper water layers being not always favorable over organic muds.

Analogous alterations take place among individuals of the same age and species. The roach, grailing and char from the upper parts of the river are found to be more spindle-shaped and to have a shorter caudal peduncle than individuals of the same species from the lower current. A somewhat different picture is presented by fishes of various ages. As a rule, the fry are morphologically more adapted to the resistance against the flow than older

specimens. But, being physically weaker, the former live lower down the stream as compared with the adults, the largest individuals being met with at the upper limit of their distribution area. Such regularities are established for a number of species, *viz.*, shovel-nosed sturgeon, *Nemachilus stoliczkai, Glyptosternum reticulatum* (G. Nikolsky, 1938; Turdakov, 1939; Hora, 1934). Such a distribution of different age groups of fishes is characteristic of rivers with rushing waters fed by glaciers. In case of the source having a slow current and being dried up in the dry season the fry are seen to predominate therein as it was, for instance, noted by Shelford (1937) for Semotilus.

The next factor of primary importance in the fish distribution in a river bed is the oxygen content of river waters. In the upper parts of the river we find fishes requiring for their respiration water highly saturated with oxygen, though some of them do not consume large quantities of that gas there. In connection with life in an impetuously rushing stream the respiratory organs of those fishes often prevent them from effecting a rapid change of water around their gills, owing to which fact the water bathing the latter must be rich in oxygen. The above peculiarity has been recorded for some Homalopteridae and some catfishes living in torrential streams (Hora, 1933).

Towards the mouth of the stream the numbers of oxiphilic fish gradually decreases (Powers, 1932). They are replaced by species which can withstand a considerable diminution in the water oxygen content. Finally downstream, mostly in tropical zones, there appear forms possessing accessory organs of respiration which allow them to assimilate atmospheric oxygen, *e.g.*, Saccobranchus, Ophicephalus, Anabas, Misgurnus and others (Hora, 1936).

The turbidity of waters due to the presence of mineral particles exerts an immense selecting influence on river fishes. While up and down stream the water is usually clear, the current of the median part chiefly in rivers of

arid regions carries the most turbid water. There, in the zone of the greatest turbidity, the fishes are very small-eyed, which is compensated by highly developed tactile organs (shovel-nosed sturgeons from the Mississippi and rivers of Aral sea basin catfishes, loaches and others). The water turbidity acts as a factor in selecting fishes with special adaptations to protect gills from being filled up with silt. In forms inhabiting muddy waters, the coagulating capacity of the mucus secreted by their skin is strongly developed.

The temperature of the river water produces also a great effect on the fish structure and habits. As a rule, cold water inhabitants are concentrated in the mountainous part of the river where, mostly in the equatorial zone, they dwell together with eurythermic forms. In the plane lower course of the river, particularly in tropics and subtropics, the number of thermophilic forms is seen to increase. Moreover, the temperature is of great significance as a form-creating factor (Jordan, 1883; Hubbs, 1922, and others). It is well known that the temperature at early developmental stages of fishes determines to a certain extent the number of their body segments, vertebrae, scales and fin rays. In some cases, therefore, individuals of the same species show a certain difference in the above meristic characters in the upper and lower parts of the stream. This particularity was observed in the brook trout, roach, dace and others. The same regularity occurs not only within a single species but in the fauna of river fishes on a whole. Thus, forms of mountainous parts have on the average a larger number of vertebrae and scales.

The change in the above-mentioned meristic characters involves an adjustment to swimming in the water of different density. This is confirmed by the fact that changes in the number of vertebrae occur in the caudal part of the spinal column only, *i.e.*, in the portion connected with the movement of the fish.

Furthermore, abiotic factors as well as biotic ones exert

a great influence on the character and distribution of the river ichthyofauna. The nature of the stream substratum determines the development of special invertebrates and plants in separate parts of the river bed.

Modifications in the character of bottom fauna and flora are associated with those in the feeding habits and structure of the fish alimentary tract (Nikolsky, 1938). In the upper course of the river where on immovable rocks and stones the periphyton and its inhabitants can develop, a considerable part of the ichthyofauna is composed of periphytonophagous forms with a long intestinal tract, a low mouth and a sharpened lower lip often invested with a cornified cover. The periphyton feeders live mostly in the mountainous regions of low latitudes, and are absent in regions of Quaternary glaciation.

Owing to the food resources (bottom invertebrates and plants being abundant for fishes in the upper parts of the river), the number of predators and fish living upon the surface food (generally insects) is rather large. Thus, according to Allen's data (1938) the insects form about 93 per cent. of the whole stomach contents in the English brook trout. Towards the lower course of the river in the region of moving bottom deposits the invertebrate fauna becomes scarcer, due to which the rôle of the surface food increases. Fishes inhabiting that region must often search their food in accessory water-bodies, mostly in creeks. The latter forms are characterized by a short intestinal tract and often by well-developed tactile organs, compensating to a certain degree the insufficiency of sight due to life in muddy waters.

Downstream the bottom fauna and flora become richer, more bottom feeders with longer digestive canals occurring in the river. In the upper and middle parts of the stream the food of the fish consists of relatively large animals, their gill-rackers being short and but slightly adapted to be a filter apparatus. Near the river mouth the significance of plankton as fish food is found to increase, which allows the fish with long and dense gill-

rackers adapted for plankton feeding to appear in the river. In the lower course forms finding their food by digging in the bottom are met with. A difference in the feeding habits exists among age groups of the same species as well.

In many species whose fry live farther down stream than the adults, the digestive tracts are much shorter in young specimens living on animal food than those of adults consuming the periphyton. The fry of many fishes inhabiting the middle course of the stream feed in accessory water-bodies because they can not find their necessary food supply (plankton) in the river itself. External conditions in separate parts of the stream largely determine peculiarities of the fish breeding habits.

The mode of reproduction of fishes in a given stretch of the river has to satisfy first two requirements, *viz.*, on the one hand to procure the most favorable external conditions of the abiotic medium, and, on the other, to defend most effectively the eggs and fry from predators. In the rapids where no well-swimming fishes can stay and where only those provided with sucking disks for adhering to stones can penetrate, the spawned eggs are found to be best protected from enemies. Therefore, near the river source most fishes glue their eggs to stones where they remain during the whole developmental period.

The next portion of the river has bottom deposits in the form of a vagile shingle. There the fishes either bury their eggs in the ground or glue them to stones for the short period of fertilization. Then the eggs are washed away and detained by pebbles, among which they develop protected from their numerous enemies. That stretch of the river contains many predators feeding upon the fish eggs (Salvelinus, Brachymystax, Phoxinus and others), which compels the fishes to hide their eggs. If the eggs remained glued to stones for a long time without being guarded, they would inevitably be devoured by predators, as was demonstrated by Berland (in litt.) in his experiments with the *Vimba vimba* eggs.

The fish mode of fertilization under the conditions of a swift current is of a specific character.

In some fishes (Schizothoracini) around their anus and anal fin a border of enlarged scales is formed which is important for fertilization in running waters. In females of such hillstream fishes as grailing Thymallus and "Osman" Diptychus a large dorsal fin may be seen which according to Brown (1938) is connected with their breeding habits.

The part of the river where eggs may develop buried in the ground, is usually very short being soon succeeded by a moving sandy bottom. The burying of eggs in the ground or gluing them to the substratum become quite impossible there.

Fishes from that portion of the river bed go upstream to the region with stony bottom or migrate into the accessory water-bodies (pools, creeks or lakes). Those parts are inhabited by forms with pelagic or bathipelagic ova which develop gradually moving downstream. Such eggs are deposited by shads, some white fish, razor fish, Ctenopharyngodon, ling and others.

The number of ova produced by fishes dwelling in the latter region is usually greater than that of those living in the upper part of the stream.

Towards the mouth where vegetation of the river bed is often abundant, fishes depositing their eggs on aquatic plants are represented by many species. Those fishes which in the middle course of the river with the movable sandy bottom generally spawn in accessory systems begin to breed in the bed alike without migrating upstream, but spawning near their feeding grounds.

Such is the scheme of main regularities determining the distribution of native forms in the stream. But in many rivers migratory species play likewise a well-marked rôle in their ichthyofauna.

In order to cover an immense distance and to reach the upper course anadromous fishes have to possess high hydro-dynamic qualities, *i.e.*, to be strong swimmers.

Inasmuch as osmo-regulation is found to disturb digestion and the fish in the river either nearly or fully cease feeding they must accumulate plenty of nutritive substances in their body to perform their migration. At the same time the higher the fish ascend the river, the more fat they must store during recuperation.

This is true for various fish groups, such as salmonids, shads, syprinids. There is a complete connection between the migratory way of fish upstream, their size and mode of reproduction.

Salmons, being the best swimmers, ascend rivers higher than other migratory species and spawn burying their eggs in the shingle. Shads possess a weaker swimming capacity and as a rule do not reach the pebble grounds of the sources, spawning mostly in the middle course of the river. Within one migratory species the same regularities may be observed. Thus, larger and fatter fishes travel to the upper part of the river, while smaller and thinner specimens spawn lower. The percentage of large and small individuals in the population of the migratory fish ascending the river, is connected with the size of the spawning area in separate portions of the river bed. In a restricted spawning area the population, spawning therein, is correspondingly reduced. The check in the fish numbers according to observations upon those of genus Oncorhynchus is achieved by a rise of the egg mortality associated with an increase in the number of reds in the same area.

This regularity becomes most conspicuous in salmons. As to the Petchora, where the principal spawning grounds are situated upstream, large autumn salmons are found to enter that river. On the contrary, in the rivers of the Kola Peninsula, where the distance from the mouth to the spawning grounds is short, salmons of smaller size are more numerous (Berg, 1935). It is possible that the homing instinct of salmonids results from a strong correlation between the length and condition of the fish and the extent of their migratory route.

The same picture may be observed among shads. In the Caspian shad, *Caspialosa kessleri,* for example, the largest specimens ascend higher in the river course, while smaller ones spawn downstream (Zamakhaev, 1944). Such are the main regularities which determine the character of the river ichthyofauna, but it is quite natural that all said above represents only a scheme subject to considerable changes due to the deposition of the erosion cycles, the geographical latitude of the water-body, climatic conditions and a number of other factors. Thus, the fact that in Eurasia the glacier line in the mountains rises higher and higher as one moves from the west to the east, contributes to a higher specialization of the ichthyofauna in the mountainous torrents of Eastern Asia, for this country was less exposed to the influence of glaciation, which in the Quaternary time allowed its ichthyofauna to stay there, without migrating to the plains. Fish with such adaptations as Homalopteridae, Sisoridae and others are not to be found in mountainous regions of Europe and North America, where the influence of the glaciers was great. In those parts the fauna is less mountainous in its adaptations.

The Origin and Evolution of River Ichthyofauna

Thus, the following important problem—the genesis of the river ichthyofauna—has been gradually approached. The ichthyofauna of torrents is undoubtedly a derivative of that of plain water-bodies with a slow downflow (Woodworth, 1894; Adams, 1901).

Undoubtedly, both the time and the conditions of the mountainous ichthyofauna origin were different. The cause of the river sources being occupied by downstream species was very often an intensive struggle for existence among those of the plains (Adams, 1901). This led to the fact that a number of forms were compelled to migrate upstream and to adapt themselves to different life conditions where competition was found to be less severe. A

high degree of competition may be explained as well by the most intensive immigration from the sea into fresh waters, which takes place in the tropical zone. In other instances migration into torrents was caused by changes in abiotic conditions in the plains which resulted in a number of fishes passing therefrom to the mountains.

After the tertiary dislocation a gradual occupation of free ecological niches of the upstream by plain dwellers began in most mountainous regions.

This process was developing very slowly and is now quite possible to follow the course of adaptation to life conditions in torrents on a number of fish groups. The above adaptations may often be so far-reaching that the return to life in plains becomes impossible (Hora, 1930).

In the regions subjected to a great influence of the Quaternary glaciation the torrential fauna may be chiefly considered as a relict of the Ice Age.

The mountainous fauna of European and North American rivers in regions of glaciation is younger than that of South America and South Asia, *e.g.*, the Himalayas. In Middle Asia two faunas differing in their origin come in contact. Thus in the mountainous regions of Tianshan, on the one hand, Cottus and Phoximus, undoubtedly ice relicts may be found, and on the other *Glyptosternum reticulatum*, the typical representative of the second group of forms, is to be found.

The fauna of the middle stream, as it was seen, has less specific adaptations to a torrential mode of life than that of the upper course. The downstream fauna, except migratory fishes, is usually indistinguishable from lacustrine inhabitants of the same regions.

The aging of the river, *i.e.*, the leveling of the up- and down-streams, results in the ichthyofauna of the latter acquiring a greater possibility to ascend higher and higher up the current extending its distribution area along the stream. On the contrary, that of the upper current is compelled to gradually reduce its area, or to become adapted to other conditions, which it finds down-

stream and which confront it with the development of the river bed.

During the earth's geological history we find a number of instances when certain groups died out, seemingly under the influence of a change in the river life conditions.

Thus, for example, the Devonian cephalaspids inhabiting running waters closely approach in appearance some reophylic armored catfishes or shovel-nosed sturgeons. It is quite possible that it was base-levelling at the end of the Devon time that caused the destruction of this reophilic group. They were quite unable to adapt themselves to the existence in water-bodies of a different type.

Another group of fossil forms which had been primarily reophylic, namely, Arthrodira, under the action of altered conditions changed its life in swift-running waters inhabited by lower Devonian Jaeckelaspis and Anarthraspis for that in streams with a slower current and even finally descended into the sea (Dinichthys Titanichthys Upper Devon) (Romer and Grove, 1935). Base levelling connected with a great climatic uniformity increases similarity between water-bodies, the latter acquiring for the most part the type of swamps.

A lesser variety of ecological conditions and an ever increasing struggle for food as well as for spawning grounds determines a greater uniformity of the fauna first in a generic respect and then in a specific one and in regard to smaller units as well.

This process seems to be connected with the dying out of a number of groups and a greater migration from fresh waters into seas.

In the course of the earth's history the above process directly associated with the formation of mountains grew alternately stronger or weaker.

Struggle for existence in fresh waters seemed to reach its highest intensity at the end of the Devon time, in particular, when a number of Cephalaspids, Pterichthyes died out, while Arthrodira passed to the sea.

In the Permian and early Triassic periods Xenacanthi,

Dipteriformes, Osteolepiformes disappeared, and Coelacanthiformes migrated into the sea.

At present this phase is passed through by water-bodies at the stage of the crucians, producing at first various biological forms, remaining finally as a single lean-bodied *morpha humilis* with a most intensive concurrence among its population. At the same time the conditions for the limnophilic fish distribution become much easier. According to Worthington (1940) many river systems were connected by means of swamps in water-shed regions, an interchange of fauna, occurring through the latter during inundations. Such a possibility may arise under the peneplenic conditions only. This allows to understand the fact that limnophilic fishes usually possess a larger distribution area than reophilic ones. Among the latter only anadromous fishes or those of marine origin, which can migrate through salt waters, have a vast area of spreading. Such a regularity is seen to exist among some other aquatic animals, in particular in Trichoptera as shown by Martynov (1929).

Thus a formation of the river ichthyofauna may be presented schematically as follows: after the formation of a river its lower parts become first occupied by fishes. These arrive from stagnant waters, being able to live downstream without changing their mode of existence and structure. As concurrence down the current increases a gradual migration upstream begins followed by adaptation to changed life conditions. The latter event modifies both the structure and habits of fishes, which results in the development of a specific fauna first in the middle stream and then at its sources. In fact, for all mountainous forms ancestors may be found in the fauna of plains.

The appearance of anadromous fishes originating from fresh waters (carps, salmons and whitefishes) seems to be connected with the extension of the stock's feeding area and an increase in its numbers resulting therefrom. Glaciation had certainly contributed to the anadromous fish passage salinity. In the period of the glaciers' re-

treat and an increase of flow from the continent to the sea considerable spaces of brook waters were formed beyond the river mouths which seemed to be primarily areas of anadromous fish recuperation. As the above region decreased with the descent of glaciers the fishes indicated retained their feeding grounds, having adapted themselves to life in salt waters. The above event serves to explain to a large degree the fact that the bulk of anadromous fishes is mostly distributed in temperate and arctic regions. A definite change to sea life proved to be impossible for those fishes, for they failed to obtain favorable conditions for reproduction in sea water. In occupying the river at the earlier stages of their development the anadromous fish fall out with the river ageing from its ichthyofauna, while in streams with a strong base-levelling the fishes in question are naturally absent, those with a higher spawning ground seeming to fall out first, those which multiply lower in the stream disappearing later.

Summary

The above statements may be summed up as follows.

(1) The main factor determining the distribution and structure of representatives of the ichthyofauna in separate stretches of the river bed is the current rate.

(2) The current rate influences the ichthyofauna in both direct mechanical manner and through alterations of other factors. In passing from source to mouth the form of the fish body, their adaptation to the oxygen content, to temperature and to a number of other abiotic environmental factors are found to change.

(3) The biotic conditions are alike of highest importance in the distribution of fish along the river. The feeding habits of the ichthyofauna bear a quite definite character in separate river regions, those adaptations changing regularly from the upper to the lower stretches of streams.

(4) Beside abiotic factors adaptations to a reproduction in various stretches of the river are largely due to

the presence of predators and to the necessity of protecting the offspring from the latter.

(5) Interrelations between fishes and abiotic as well as biotic factors are most intimately with each other, the effect of the former being often expressed by changes in the latter and *vice versa*.

(6) The anadromous fish are subject to the same actions as the native ones. In visiting the river for reproduction they reach such grounds where their ova find the most favorable conditions of development.

(7) The structure and habits (the mode of egg-laying adaptations for fertilization, etc.) of diverse anadromous fishes are connected with the situation of their spawning grounds along the river course. Larger and stronger specimens ascend the river higher than smaller ones.

(8) The ancestral forms in the ichthyofauna of rivers, particularly those of their mountainous stretches, are inhabitants of water-bodies with a slower flow, becoming gradually adapted to live first downstream, then in the middle stream region and finally near the source.

(9) The causes of immigration into the river from the sea or lakes and ponds are either an increasing struggle for existence in the latter water-bodies or some changes in their abiotic conditions compelling the fishes to leave their primary distribution area.

(10) The ichthyofauna in the mountainous part of the stream is found to be the most specialized of all the ancestral types, reaching the highest degree of specialization in those regions where the Quaternary glaciation had not forced the above ichthyofauna to descend to the plains (South Asia and South America).

(11) In Europe and North America, where the action of glaciers caused the mountainous fauna to migrate into plains, that fauna is less specialized, becoming stenothermic, *i.e.*, a relict of the Ice Age.

(12) The mountainous ichthyofauna of extraglacial regions frequently exhibits such profound structural modifications connected with life in torrents that it dies out when those conditions are changed.

(13) Instances of the destruction of a specialized representative hill-stream fauna may be found during the geological history, *e.g.*, the dying out of the Cephalaspides, which had taken place in the Devonian time.

(14) The periods of the earth's history, when the base-levelling and the formation of water-bodies mostly of a swamp and lake type are connected with a disappearance of a number of fresh-water fish groups and more strenuous migrations from inland waters into the sea.

(15) Periods of an intensive dislocation and formation of new river basins are those of mass migrations of fishes from the sea into inland waters and of their rapid speciation in the latter.

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REVIEWS AND COMMENTS

EDITED BY CARL L. HUBBS

In these reviews and notices of current biological publications emphasis is given to books and major articles which fall within the special scope of THE AMERICAN NATURALIST, in that they deal with the factors of organic evolution. REVIEWS AND COMMENTS are meant to include also such general discussions, reports, news items and announcements as may be of wide interest to students of evolution. Except as indicated, all items are prepared by Dr. Carl L. Hubbs, Scripps Institution of Oceanography, University of California, La Jolla, California. All opinions are those of the reviewer.

The Australopithecinae. By R. BROOM AND G. W. H. SCHEPERS, with a Preface by J. C. SMUTS. Transvaal Museum Memoir No. 2, Pretoria. 4to. Part I, The Occurrence and General Structure of the South African Ape-Men, by R. BROOM: 7–153, pls. 1–13, figs. 1–23.

IN ANTHROPOLOGY every major discovery has been as it were a golden apple of discord among anthropologists. To go back no further than Linnaeus his placing of man among mammals and especially his allocation of man to the order Primates, along with lemurs, monkeys and apes, was altogether too much for most of the learned dons and courtly professors of his time. And even today but few anthropologists when using the word "Primates" include man. For whatever man's deeper anatomical kinship with the ape's may be *Homo sapiens* is usually unwilling to recognize his poor relations and in days now not wholly past even some eminent anthropologists developed a pithecophobia which predisposed them to lean over backward whenever new discoveries were claimed to lessen the gap between ape and man.

The truly epochal discovery of the type skull of *Australopithecus africanus*, the first known South African man-ape, was announced by Prof. Raymond Dart of the University of the Witwatersrand, Johannesburg, in *Nature* of 7th February 1925. In comparison with the type skulls of *Pithecanthropus*, Neanderthal and Piltdown, Dart's type was an amazingly well-preserved skull of a child ape, including the entire face, most of the lower jaw, all the milk teeth and the first true molars above and below. Dart, as it now seems, on the whole correctly

assessed and interpreted the differences from young gorillas and other apes and saw that the teeth were prevailingly human, as were the brain cast and skull. He suggested in substance that *Australopithecus* was an upright-walking, relatively large-brained higher primate, more advanced than any known ape, more primitive than any hitherto discovered early man and that it offered objective evidence in favor of Darwin's hypothesis that man may have originated in Africa.

But his English friends and colleagues, Sir Arthur Keith, Professor Elliot Smith, Sir Arthur Smith Woodward and Dr. W. L. H. Duckworth and others raised many doubts and called for further evidence. Dr. Schwartz, a mammalogist, held that Dart's young ape was a new species of gorilla. Hrdlička after careful field studies at Taungs, the site of the discovery, concluded that "the skull itself is that of an anthropoid ape approaching rather closely in size and form the chimpanzee, but in all probability it is a new species if not genus of the great apes." W. Abel, relying on the law of irreversibility of evolution, held that *Australopithecus* represented a wholly extinct end form, which merely paralleled man in some features. But Broom, Sollas and the present reviewer defended Dart's view that *Australopithecus* was at least a structural intermediate between ape and man.

Meanwhile Dart's friend and colleague, Dr. Robert Broom, had been engaged chiefly in his medical practise and in describing very many new species of South African fossil mammal-like reptiles. But in 1934 General Smuts and Mr. Hofmeyer had him appointed to a post in the Transvaal Museum. In 1936 he began searching in one of the limestone quarries of the region near Krugersdorp between Pretoria and Johannesburg. A little later two of Professor Dart's students, H. le Riche and G. W. H. Schepers, visited a quarry at Sterkfontein near Krugersdorp and obtained some fossil baboon skulls there. It was there also that G. W. Barlow, in charge of the limeworks, gave Broom three nice little fossil baboon

skulls and much of the skull of a large sabretooth tiger which had been blasted out of the bone breccia that was being burned for lime. A few days later in August 1936 Mr. Barlow handed Dr. Broom the blasted-out natural brain cast of an anthropoid. This was the first relic of Broom's *Plesianthropus transvaalensis* and it was soon joined by the base of the skull, the upper jaw, parts of the face and eventually other valuable pieces.

Broom's type of *Paranthropus robustus* was discovered by a school boy, Gert Terblanche, at Kromdrai near Sterkfontein. When Dr. Broom finally got in touch with him Gert had four beautiful fossil teeth in his trouser pocket, while Broom had the palate and other teeth in *his* pocket. Together they recovered a good part of the base of the skull, the bony face and lower jaw, but the top of the skull had been weathered away.

Broom's memoir published in January 1946 affords detailed documentation for all the South African man-apes including concise descriptions and very clearly drawn figures, all by the author, from the originals; he also describes and figures the various fossil mammals from the Taungs, Sterkfontein and Kromdrai caves. These are most nearly related to existing African forms, but their possible relationships with the fossil mammals of India, China and southern Europe need much augmentation and further study, before adequate judgments as to the geologic ages of these deposits can be made. Broom, on the basis of present evidence, very tentatively suggests that Taungs is of possibly Upper Pliocene age, Sterkfontein possibly Middle and Kromdrai possibly Upper Pleistocene.

To summarize broadly: In Dart's young ape, as he clearly recognized, the skull and dentition are in general almost human and more progressive than those of any other known ape. On the other hand the estimated size of its brain (500 cc.) comes a little within the upper range of the apes (550). The deciduous teeth and especially the anterior lower permanent premolar are decisively

human. The first permanent upper and lower molars are transversely broader and rounder than in apes, yet they retain the principal cusps and grooves of the "*Dryopithecus* pattern," but with a definite approach to the plus pattern of man.

In Broom's adult male *Plesianthropus* type the estimated volume of the brain (650 cc. average) was just within the upper range for the gorilla, but the general contour of the brain was more human looking, as were also the dental arches.

Broom's *Paranthropus* was definitely more manlike than was *Plesianthropus* and estimates for its brain capacity were somewhat higher (575–680 cc.). It was highly peculiar in having very forwardly placed and deepened malar bones, a concave facial profile and a unique flattening and widening of the subnasal region. After examining the original the reviewer agrees with Broom that this flattening was not due to postmortem deformation. Taken collectively these features suggest a strongly protrusile upper lip. From various lines of evidence Broom infers that the Australopithecinae already walked erect.

The problems of the relationships of the Australopithecinae on the one hand to the anthropoid apes (including the ancestral Dryopithecinae of the Miocene and Pliocene of Europe and India) and on the other hand to man ramify in many directions. The answers already given vary not only in accordance with the background, standards and particular experience of the specialist, but especially according to the postulates and principles of evolution by which he guides his reasoning. To Wood Jones, man's nearest known relatives were not any of the anthropoid apes living or extinct but the lower Eocene tarsioids. To Keith, Osborn and Broom, the common ancestor of man and the living apes may well be the little *Propliopithecus* of the Lower Oligocene of Egypt or possibly even some Eocene precursor. Weidenreich also regards the Dryopithecinae as the ancestors only of the

true apes and agrees with the others in looking for an unknown pre-Dryopithecine common ancestor, near or remote. The reviewer, however, is impressed by the vast web of annectant characters between all known apes, recent and fossil, Australopithecinae and man. Rather than postulate many unknown and hypothetical intergrades between *Propliopithecus* and man and thus perhaps fall into the error known as *ignotum per ignotius* the reviewer has often cited the extensive evidence tending to show that there was a profound transformation, not only in the brain, which is admitted by all, but in the canines and first lower premolars, which is disputed by Broom and Weidenreich, in the first deciduous molar, which is disputed by Broom, and in the feet, which has been disputed by Wood Jones and by Miller, but supported by Weidenreich, Morton, Raven and the reviewer.

Not to forget Broom's other Herculean labors on the vertebrate fossils of South Africa, this splendid work of genius must inevitably inspire other investigators to push forward in this field. Broom's conclusion opens wide the doors to these South African treasures to his colleagues in other countries. What is now needed he shows is not a one-man project, but a long-continued systematic search for new fossiliferous caves and even for patient sifting of the old quarry dumps in which valuable fossils lie buried.—William K. Gregory, *American Museum of Natural History, New York, N. Y.*

The New Genetics in the Soviet Union. By P. S. Hudson and R. H. Richens. Cambridge: Imperial Bureau of Plant Research and Genetics, 1946: 1–88. 6 shillings.

P. S. Hudson and R. H. Richens have performed a valuable service to biologists and agronomists alike by making available in English a review not only of Lysenko's theories but also of the peculiar circumstances that made possible a rather wide acceptance of these theories in the Soviet Union. More important still, the authors give a concise but painstaking and critical sum-

mary of the large array of data published in Russian journals in recent years which have been claimed by Lysenko as evidence for his beliefs. The magnitude of the work performed by Hudson and Richens may be guessed from the list of 222 references in their bibliography to papers and books published in U.S.S.R. alone (most of which are, incidentally, either rare or unavailable in this country).

Throughout the book the authors preserve an open-minded and impartial attitude as well as a calm and restrained tone in the exposition and discussion of Lysenko's views and their supposed verifications. Indeed, in the opinion of this reviewer, the authors often lean backward in their readiness to concede to Lysenko the benefit of doubt even in cases where the chances of his being even partly right seem to be infinitesimal (for example, the alleged induction of mutations in cereals by planting these at different seasons, see pp. 38–41). Notwithstanding these concessions, the net effect of the survey on Lysenko's doctrines and their ostensible factual basis is devastating. As in the well-known tale of Andersen, the king's fancy dress which only clever people can see proves to be simply non-existent.

One closes this book with a heavy heart. It shows that dozens and possibly hundreds of investigators in the institutions and laboratories directed or influenced by Lysenko have been misled to fritter away their intellectual energies and their youthful enthusiasms. The misfortune is not so much that these sincere seekers of truth have been made to pursue fictitious goals; worse still, they were taught to use methods of approach to scientific problems which make the results of their endeavors very nearly worthless. It is enough to mention in this connection the denial by Lysenko of usefulness of statistical methods. Yet, most of the data alleged to support Lysenko's views are quantitative. The habitual use of what Hudson and Richens aptly call "alogical discourse" is even more pernicious. In the opinion of the present re-

viewer, Hudson and Richens have erred in ascribing some of Lysenko's fallacies to his use, or rather misuse, of the Marxian dialectics. Other biologists who claimed to follow this philosophical system have not been led astray by it. Lysenko probably will seize this opportunity to misrepresent the opponents of his biological theories as enemies of the dialectic method in general.

It is unnecessary to discuss here the motives behind the actions of Lysenko and his principal abettors (such as I. I. Present), but it is unfortunately a matter of record that they played havoc with that part of the biological science in U.S.S.R. which came under their sway. Fortunately, this sway neither is nor was country-wide. The steady output of first-class original work in genetics and related fields published in both Russian and foreign scientific periodicals proves this conclusively.—Th. Dobzhansky, *Columbia University, New York, N. Y.*

Handbook of Lizards. By Hobart M. Smith. Handbooks of American Natural History, Vol. 6. Ithaca, N. Y.: Comstock Publishing Co., 1946: i–xxi, 1–557, figs. 1–136, pls. 1–135, maps 1–41. $5.75.

This is a well-designed and complete work on the lizards of the United States and Canada, fully justifying the expectations of those who have long awaited its publication. It is virtually unique in its field, as, for a long time, no adequate work has been available on the American species of this interesting group of animals. It will be indispensable to all herpetologists, whether amateur or professional, and should do much to stimulate future studies of lizards in this country.

Smith's book begins with a valuable introduction discussing the lizards as a group, first from the anatomical standpoint, followed by sections on descriptive terminology, life history and habits, collecting, preserving, etc. An interesting item is the presentation of problems warranting future investigation, which problems are also mentioned under the several species involved.

The body of the book contains descriptions of each of the 136 species and subspecies found in the United States and Canada. The description under each varies from complete to somewhat inadequate, depending on the material available to the author. Most of the descriptions include the following topics: Range, size, color, scalation, recognition characters, habitats, habits, problems, races. The generic keys are adequate and well illustrated, although occasionally somewhat difficult to follow. The species keys are highly useful, although it will probably be found, as Smith himself has pointed out, that occasionally distributional ranges must be considered an important part of a key, particularly in differentiating subspecies; otherwise individual specimens will fail of proper classification. Published data on habits are quoted extensively.

The descriptions are strengthened by the use of both photographs and line cuts. Many of the half tones leave something to be desired, since there apparently has been a considerable loss of clarity between the original photographs and the final half tones. Because of the variability of lizard scalation and the fact that the homologous scales in the different genera are not easy to correlate, the user of the book will appreciate the line drawings, for although many have been taken from the earlier works of Cope and others, Smith has improved them by incorporating appropriate legends giving the names of the important scales. These will be of considerable aid in interpreting keys.

Following the descriptive material, there is a set of 41 distributional maps which are clear and well prepared, and will be found highly useful. The final map shows the number of species and subspecies of lizards found in each state, and serves as an impressive reminder of the fact that these saurians distinctly prefer not only a warm but an arid climate, although it should also be recognized that the supremacy of California, Arizona, Texas and New Mexico, in the order named, is partly the result of the varied topography present in those states.

The book closes with an adequate bibliography, divided into three sections, general literature, state lists, including references under each state, and finally, literature cited. I found this subdivision unnecessarily confusing. It would be more useful to have had a single bibliography, repeating, under each state reference list, an abbreviated reference to each title, thus permitting its location in the general bibliography. This is not to dispute the value of the state lists, which is unquestioned.

A few misprints have been noted, but in general the proof reading has been good, and the publisher is to be congratulated upon the typography and general appearance of the work.—L. M. KLAUBER, *233 W. Juniper St., San Diego, California.*

Plants and Plant Sciences in Latin America. Edited by FRANS VERDOORN. Waltham, Mass.: The Chronica Botanica Co., 1945: i–xxxvii, 1–383, pls. 1–38, maps. $6.00.

"INVALUABLE," Mr. Henry Wallace is reported to have said of this book. "Inimitable," comes closer to my own feelings, which are thoroughly mixed. It is quite true, as other reviewers have pointed out, that "Plants and Plant Sciences in Latin America" represents the fruit of remarkably good intentions and Herculean effort on the part of Mr. Verdoorn and his contributors. "The aim of this collection of articles which we started in 1941 in Chronica Botanica was to give the agronomist, botanist, forester and phytopathologist . . . information which he may need when starting work on the wild or cultivated plants of Latin America. It was hoped that it might be still more useful for those who plan to go to Latin America to collect or to conduct research. The collection endeavored to give some information concerning the present status of and the future possibilities and needs for research in the pure and applied plant sciences. In addition to data in his own field, the specialist will find much useful and stimulating information on vegetational and agronomic problems in general, . . lists of books, . .

addresses of institutions and societies, . . etc." In these aims, the book may have succeeded to a degree, but one can not convey an adequate impression of it by isolating its good qualities from its faults in an orderly and logical way because, I am afraid, those adjectives do not fully apply to it.

The statistics of "Plants and Plant Sciences" are truly awe-inspiring. Within an octavo volume of about 400 pages, rather annoyingly printed, two columns to the page, in small, solid type, are collected the observations of 85 contributors, 53 of whom are citizens or residents of the U.S.A., 5 each of Great Britain and Brazil, 3 each of Argentina, Cuba and the Netherlands, 2 each of Uruguay, Salvador and Mexico, and one each of Bolivia, Ecuador, Colombia, Venezuela, Sweden, France and Paraguay. In addition to papers by the contributors, there is a dedication to von Martius and an ode to Agriculture in the Torrid Zone by Andres Bello (*ca.* 1810), both in Spanish; an introductory essay on "The Plant Scientist in the World's Turmoils" by the editor, and several bibliographical supplements and indices. Mr. Verdoorn has spared no pains in obtaining, in most instances, the highest quality among his contributors, and the papers, almost without exception, are well written and have the ring of authority within the narrow limits allotted to them. Seventy of the contributions are written in English, 14 in Spanish and one each in French and Portuguese. The reader should be thankful to Dr. Lily M. Perry for her translation of Dr. Stahel's paper on Surinam out of the Dutch. Singularly, Dr. Perry's name is omitted from the roster of contributors on the title page.

Impeccable as are the aspirations of "Plants and Plant Sciences," and gifted as are the contributors, in my opinion the printed book is scarcely more than a grab bag. Admitted that the number of contributors and the gamut of their subjects, let alone their confusion of tongues, really present a problem of synthesis, why was it necessary to divide the papers into "Pars I" and

"Pars II," both covering essentially the same variety of subject-matter, but the first consisting "primarily of articles not previously published . . . in Chronica Botanica" and the second "mainly of articles previously published in Chronica Botanica"? Through this major innovation, for example, one encounters in Pars I "The Vegetation of Honduras" by T. G. Yuncker, which is followed by "Idea General de la Vegetacion de El Salvador" by P. Anton Kovar. Later, in Pars II one reverts to "Plant Resources of Honduras" by Wilson Popenoe, which is followed by a paper on the vegetation of Guatemala by Standley. And so, throughout the book, one jumps from subject to subject, guided only by what had, and what had not been published previously in Chronica Botanica.

Within each part the arrangement is somewhat more logical, the chapters being arranged, one is informed in the "Detailed Table of Contents" at the end of the volume, into "Regional Descriptions" and "Chapters of a General (Non-Regional) Interest." The scope of the latter is almost infinite, botanically speaking, including such topics as geological history, climatology and meteorology, soils, soil conservation, plant pathology, "Food Aspects," ethnobotany, Hevea rubber culture, Chinchona culture, fat and oil resources, the species problem, agricultural scholarships, "Grazing versus Soiling in the Wet Tropics," etc., etc. In short, much too many topics to be presented comfortably in such little space.

Amongst the regional descriptions one is able to discern two types in general, one including chiefly floristic data and the other largely economic botany. Both types, however, frequently entail physiographic and ecological summaries which are sufficiently different, when dealing with a given country, to cause some confusion. This is almost inevitable, since each country or colony is allotted two "regional descriptions," one of each type, and the two seldom are compiled by the same author.

The very number of chapters, in addition to the variety

of subjects, necessarily prevents individual evaluation. However, the "Phytogeographical Sketch of Latin America" by Smith and Johnston should be read by all who are interested in a short, easily digested summary of this enormous subject. This chapter impresses me as being perhaps the most valuable single portion of the book from the standpoint of "pure" versus "applied" plant biology. Another almost equally valuable chapter, and also very easily read, is Pennell's "Historical Sketch" (of plant exploration), which, like the former, becomes a "must" on the reading list of advanced students dealing with Latin America.

Since they occupy a conspicuous place in the book, attention should be paid to the numerous illustrations consisting of maps, original and otherwise, photographs and intriguingly antique sketches. The sketches, particularly, one feels to delight the editor, who anticipates in his foreword, "I do not flatter myself with the hope that my choice of plates and certain other details of typography will meet with universal approval. Being daily engaged in historical work, one tends to live partly in the past and finds there without doubt much which may seem strange to some whose mental activities are centered more in the present." It is in this admission of the editor that one finds a clue to his book's air of other-worldliness, and why it may be of less use to many of its intended readers, say, than "A Naturalist's Guide to the Americas."

A final symptom of Rafinesquian "preoccupation" is provided by the "Complete and Detailed Table of Contents (as it was not feasible to prepare a subject index for our polyglot volume, it is important that every reader examine this table of contents with some care!)." Here two closely corresponding synopses of the entire book are provided, one each for "Pars I" and "Pars II." One feature deserves a word of caution, however: the biographical statistics provided each author, including undergraduate and postgraduate degrees, professional ap-

pointments, past and present, etc., etc. Amongst these one may discover numerous errors, both of understatement and overstatement, particularly with regard to professional appointments.—R. E. Woodson, Jr., *Missouri Botanical Garden, Washington University, St. Louis, Missouri.*

Water Bacteriology, with Special Reference to Sanitary Water Analysis. By Samuel Cate Prescott, Charles-Edward A. Winslow and MacHarvey McCrady. 6th Edition. New York: John Wiley and Sons, 1946: i–xiv, 1–368. $4.50.

Extensive advances have been made in the sanitary examination of water since the last edition of Elements of Water Bacteriology appeared in 1931. These advances in analytical procedures, terminology, observational data and interpretation of results have been summarized in a scholarly manner along with earlier knowledge of the subject in such a way as to produce a most useful textbook. The scope of the book—as of earlier editions—is limited to the public-health aspects of the subject, the emphasis being upon the distribution, behavior and sanitary significance of organisms introduced into water from extraneous sources. The objectives of the authors to provide a historical and philosophical background for adequate comprehension of the meaning of methods of water analysis, a textbook for the student, and a source of reference for the laboratory technician and research worker have been richly realized.

Approximately half of the text is devoted to a discussion of coliform organisms; their detection, enumeration, identification and significance in water. Although presenting an amazing amount of information on this important group of bacteria, the authors subjugate details to the elucidation of general principles of practical importance. Also admirably treated are aerobic streptococci, spore-forming anaerobes and other intestinal bacteria as indices of pollution. Numerous examples are chronicled of the isolation of typhoid, paratyphoid and dysentery organisms from water or sewage.

Besides the chapters dealing with enteric organisms found in water and sewage, there are chapters on the bacteria in natural waters, the collection of samples for the bacteriological examination of water, methods of determining the numbers of bacteria in water, the applicability of bacteriological data to problems of sanitation, the bacteriology of sewage, and the bacteriology of shellfish. An appendix of tables for obtaining the most probable number of bacteria in water samples from dilution data will serve a useful purpose. A bibliography of 903 references complete with titles, but unfortunately not giving the inclusive paging, makes this edition of Water Bacteriology an invaluable reference work.—CLAUDE E. ZOBELL, *Scripps Institution of Oceanography, University of California, La Jolla, California.*

The Genus Bazzania in Central and South America. By MARGARET FULFORD. Waltham, Mass.: The Chronica Botanica Co. (New York: G. E. Stechert and Co., agents), 10(6), 1946: 1–62. $2.00.

FORTY-six species of this world-wide genus of hepatics are listed as occurring in the area treated, of which seventeen are new combinations from *Mastigobryum*. Descriptions are full, habitat notes are included, and distributions are as complete as the limited material allows. Synonymy is extensive, but incomplete, since some European types were not available. The line drawings which illustrate specific characters are well executed. The work is well printed.

The distributional facts are briefly summarized, but, as Miss Fulford points out, few accurate statements of range "can be made at this time, since our present knowledge of the occurrence of the plants represents a 'distribution of collectors'." Nevertheless, one is impressed with the similarity of the emergent patterns to the well-known and often repeated patterns of the seed plants, as was suggested by Sharp (Lilloa, 10, 1944) to be true of mosses. Analysis of the distributions suggests that the relationships of the Antillean species lie with South

America rather than with Central America. Those of the Greater Antilles appear to lie with the Andes, which is true of groups of flowering plants highly endemic in the islands. The pattern within the islands themselves is the familiar one of varied combinations of locality, rather than the generalized pattern one might expect for wind-borne germules lying in the track of tropical hurricanes. The wide disjunction of some species to the paleotropics, particularly of the section *Vittatae,* is intriguing. It would appear that Miss Fulford has made the most of the limited material at hand, a fact which stresses both the paucity of the basic data and the need for equally competent revisions of this type.—Carl Epling, *University of California, Los Angeles 24, California.*

The Society for the Study of Evolution

This society was formally organized on March 30, 1946, during the meeting of the American Association for the Advancement of Science at St. Louis. The object of the new society is "The promotion of the study of organic evolution and the integration of the various fields of biology interested in evolution." Among the founders were representatives of the fields of genetics, paleontology (vertebrate and invertebrate), taxonomy (plants and animals), ecology, and related sciences. The elected officers represent these various fields. The officers for the year 1946 are: President, G. G. Simpson; Vice Presidents, E. B. Babcock, A. E. Emerson and J. T. Patterson; Secretary, Ernst Mayr; Treasurer, K. P. Schmidt (Chicago Museum of Natural History); Council, E. R. Dunn, H. J. Muller, Sewall Wright, G. L. Jepsen, Th. Dobzhansky, and R. Chaney.

The society is an outgrowth of the Society for the Study of Speciation and of the National Research Council Committee on Common Problems of Genetics, Paleontology and Systematics. It is open to all individuals interested in the study of evolution. All those will be listed as charter members who join before the first annual meeting, December, 1946. Dues for the year 1946 were set at $1.00. The society plans, beginning in 1947, to publish a quarterly journal and to raise the dues to include the subscription. Such a journal should be a major factor in bringing together the now widely scattered contributions to evolutionary

biology. The society will hold an annual meeting in conjunction with the A.A.A.S. It will also endeavor to further the progress of evolutionary research through sponsoring symposia and through standing committees. The society has two complementary integrating functions. One is to bring together various fields of biology that are interested in evolution. The other is to bring together the various schools that are flourishing in different countries. That the membership has grown to nearly 400 without a campaign indicates the need that has existed for such an organization. Applications for membership and all other communications should be addressed to the Secretary.

The Princeton Conference on Genetics, Paleontology and Evolution

In connection with the Princeton University Bicentennial Celebration there will be held at Princeton, on January 2 to 4, 1947, an international conference on genetics, paleontology and evolution. The personnel of the conference will include the 29 members of the National Research Council Committee on Common Problems of Genetics, Paleontology, and Systematics and about 30 other invited guests. The conference will aim to summarize recently acquired knowledge and to point out profitable lines of future investigation. Princeton University plans to issue a small brochure to summarize the discussion and the National Research Council committee hopes to publish a symposium volume to include, among other contributions, some of the material presented at the conference.

Pacific Science, a New Journal

The University of Hawaii announces the publication, beginning with January, 1947, of a new quarterly journal, *Pacific Science*, to be devoted to the biological and physical sciences of the Pacific region. Subscriptions, in amount $3.00 per year, may be sent to the University of Hawaii, P. O. Box 18, Honolulu, Hawaii. Dr. A. Grove Day, of the university, is editor-in-chief, and a board of editors represents the various sciences.

SHORTER ARTICLES AND DISCUSSION

THE SYMBIONT THEORY IN EXPLANATION OF THE APPARENT CYTOPLASMIC INHERITANCE IN PARAMECIUM

RECENTLY it has been shown by Preer (1946) that the bodies responsible for the killer effect in *Paramecium aurelia* (the kappa factor) are rather limited in number (about 250 per Paramecium). There are about the same number of green bodies in *P. bursaria*, and this remarkable correspondence in number suggests that the colorless bodies in *P. aurelia* and the green symbionts in *P. bursaria* might be related. Perhaps the colorless bodies are present in some strains of *P. aurelia* but not in others. (The green symbionts are sometimes not present in *P. bursaria*.) This would account for the fact that some strains show evidence of apparent cytoplasmic inheritance; others do not. On the other hand, the bodies in question might be present in all strains of *P. aurelia*, but they might be manifest only in those strains of *P. aurelia* in which a mutation in these bodies produced a special effect, such as the killer effect or an effect on mating type. The "normal" effect of the colorless bodies would be the result of some processes, perhaps nutritional, common to all strains, and therefore not ordinarily evident in heredity.

The original green symbionts in *P. aurelia* would undoubtedly have had a purely nutritional relationship to the host cell, but after they lost their color they might have continued to have some useful relationship, perhaps still nutritional (as in the manufacture of vitamins) and this would now constitute the normal effect of the colorless symbiont, the killer action as above stated being a special effect. It would not be at all surprising if a mutation in the colorless symbiont and a gene mutation had similar effects, say on mating type, since, within the nuclear gene system itself, mutations in different genes can have similar effects on such traits as size; or, better, since even the environment can produce imitations of mutations (phenocopies). In the present case we can refer to the imitations produced by the symbionts as *cyto-copies*. If we grant the possibility of cytocopies, then in *P. aurelia* the same traits might show apparent cytoplasmic inheritance in some strains (those in which the muta-

tions involved the symbionts) but exclusively nuclear inheritance in others (those in which the mutations involved nuclear genes).

The occurrence of green symbionts is very widespread among the ciliates. It is therefore possible that the green symbionts of *P. bursaria* and the supposed non-green ones in *P. aurelia* were derived from some common ancestor in ciliate evolution. In some lines, then, the symbionts would have remained green; in others they might have lost their green color but still have continued as symbionts,and even have acquired new properties; and in still others they might have got lost. Moreover, it would not be surprising that some nuclear gene mutations would result in cytoplasmic conditions unfavorable for the continued growth of the symbionts, thus leading to their loss, especially in view of the well-known occurrence of host-parasite (as well as host-transplant) incompatibilities dependent upon single gene substitutions. This then would result in the finding that the multiplication of the "cytoplasmic factors" depends upon particular nuclear genes.

In a previous article (1946) the writer suggested that the kappa factor was possibly a viroid (a useful symbiont related to a virus). This is still a possibility, but in view of the numerical correspondence above referred to, the suggestion now being made seems more likely. The two suggestions have an important point in common; namely, that the kappa factor is a *symbiont*, rather than a plasmagene. A symbiotic relationship of some sort is indicated by the relative independence of the kappa factor and *Paramecium,* as shown both by their independent division rate (in Preer's races) and by the ability of the one (*Paramecium*) to live without the other (the kappa factor). Certainly the kappa factor cannot represent any important element of the gene system proper of the Paramecium and it is therefore more probably a symbiont.

EDGAR ALTENBURG

THE RICE INSTITUTE
HOUSTON, TEXAS

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THE ABSENCE OF A PRIMARY SEX FACTOR ON THE X-CHROMOSOME OF DROSOPHILA

THE problem of determining the existence or non-existence of a single primary sex factor on the X-chromosome of *Drosophila melanogaster* was studied extensively by Patterson and coworkers (Patterson, 1931 and 1938; Patterson, Stone and Bedichek 1937). In addition to studies with gynandromorphs, a plan, first suggested by Muller (1930), was used by these workers. This consisted of combining the right and left halves of the X-chromosome from different translocation stocks so that a short overlap occurred. If the region so duplicated contained all, or a large part of, the sex-determining potency of the X-chromosome, diploid flies with this region present in duplicate should be female, regardless of whether the rest of the X-chromosome was single or double. The entire X was studied region by region by the use of successive overlaps, and in all cases where viable hyperploids were produced the flies were male. However, viable flies containing a tiny region between *garnet* and *pleated* (from 13A2 to 13A6 on Bridges' map) in duplicate were never obtained.

A different method of attack was tried by Dobzhansky and Schultz (1934), who studied the effect of parts of the X-chromosome present in triplicate in shifting the type of triploid intersexes. When certain regions were present in triplicate there was a shift in the intersex type, but the middle region of the chromosome could not be studied with the stocks then available. Pipkin (1940), using the technique of Dobzhansky and Schultz and making use of the translocations obtained by Patterson and his coworkers, was able to study the center region which neither group of workers had been able to study. She obtained flies with this region present in triplicate, the rest of the X in duplicate, and with three sets of autosomes. These were all intersexes, but the numbers were too small to determine if the mean intersex type had been shifted.

Although this experiment seems to rule out the possibility of a single factor, it was decided to attempt to obtain additional evidence by completing Patterson's experiments of duplicating small regions in diploid flies. The unusually high viability of males hyperploid for the extreme right end of the X chromosome (Patterson, Stone and Bedichek, 1937) suggested duplicating this

region along with the unstudied part. The excess of viability of flies hyperploid for one part might compensate for the apparent weakness of flies hyperploid for the other. It was suggested by Professor W. S. Stone, to whom the author is greatly indebted, that this might be accomplished by inducing a deletion in the right part of the X-chromosome of an X–IV translocation broken to the left of the *garnet-pleated* area. Also, it was decided to attempt at the same time to obtain a deletion in the left part of a translocation broken to the right of the region, though there was less reason to expect flies hyperploid for such a chromosome fragment to live. As no viable hyperploids were obtained from the first experiment, only the latter will be reported.

In this experiment translocation 4 was used. This is a reciprocal translocation between the X and fourth chromosomes in which the X is broken just to the right of *scalloped* (13F5). Males with this translocation and carrying the mutant *Bar* were X-rayed and mated to attached-X females homozygous for the genes *yellow*, *vermillion*, *garnet* and *forked*. Among the offspring, deletions of the desired type were recognized as *vermillion forked* hyperploid females. These were mated to *yellow* males. In two of the deletions non-*yellow* hyperploid male offspring were produced. The fact that these were male confirms the findings of Dobzhansky and Schultz and of Pipkin and eliminates the possibility of a single primary sex factor.

In each case a large number of hyperploid males were tested and were found to be phenotypically normal and of high viability, but were sterile. The reason for the sterility is not known. There is a possibility that the breaks induced were complex and included additional deficiencies, but the likelihood of this happening on two separate occasions is so small as to be negligible.

Additional evidence of the multiplicity of sex-determining genes, both on the X-chromosome and the autosomes, has been accumulating through the finding of mutations altering the sex or shifting the intersex type (Dobzhansky, 1930; Lebedeff, 1934, 1938 and 1939; Pipkin, 1942; Dobzhansky and Spassky, 1941; Stone, 1942; Sturtevant, 1921 and 1945; and Gowen, 1946).. It is reasonable to assume, because of the small proportion of neomorphic mutations so far observed in Drosophila, that the normal alleles of mutants that affect sex differentiation are in general themselves concerned with sex. In the light of all the evidence

now at hand, the multiple sex gene theory of Bridges is well established.

JAMES F. CROW

DEPARTMENT OF ZOOLOGY
DARTMOUTH COLLEGE

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AN ESTIMATE OF THE TOTAL NUMBER OF BEACH-MICE OF THE SUBSPECIES *PEROMYSCUS POLIONOTUS LEUCOCEPHALUS*, OCCUPYING SANTA ROSA ISLAND, FLORIDA

POPULATION size is an important factor in the differentiation of plant and animal kinds. Small size permits random divergence due to chance fixation of non-adaptive characters and due to some extent to differential mutation pressures (Wright, 1938). Large size acts, in general, to prevent random, non-adaptive differentiation. A reliable estimate of the total number of individuals that comprise an isolated species or subspecies of mammal

is, therefore, of considerable importance. Such an estimate of the total of beach-mice (*Peromyscus polionotus leucocephalus*) on Santa Rosa Island, Florida, may be made from live-trapping data that were obtained in the winter of 1941 and the spring of 1942. The Santa Rosa Island population, which is strikingly differentiated from related populations of the nearby mainland, is ranked as a subspecies by most taxonomists (Sumner, 1926). Because the subspecies *leucocephalus* occurs only on the island, we are able to estimate the total number of individuals that comprise this well-differentiated subspecies.

The data on which the estimate is based were obtained by trapping, marking, releasing, and re-trapping the mice on a measured segment of the long, narrow reef of white sand that is Santa Rosa Island. These data will be published at a later date. The area sampled comprised a little over 1/150th of the total area of the island. In length, the segment comprised approximately 1/135th of the total length of the island. The sample area is proportionately larger and consequently gives a more accurate estimate than is possible with most species and subspecies of mammals, which ordinarily occupy large geographic areas.

The principal source of error in such an estimate is the unequal density of the population in different habitats. The beach-mice are more concentrated in the grassy dunes flanking the beach than they are in the more open interior of the island. They live rarely, if at all, in the small patches of marsh that occur throughout the length of the island. We can estimate the total population of the island from the present data if we assume that the ecological communities mentioned above occur in the same relative frequency throughout the length of the island. Extensive field observations indicate that this assumption is justified.

The total population of beach-mice of the subspecies *leucocephalus* may be estimated directly from the number of mice trapped on the stated fraction of the total area of the island (Table 1). Another estimate can be made from the number of mice trapped along the stated fraction of the total length of the island. The raw data will be the same in either case, and the only difference is in relating the sample area to the total area of the island. The estimate based on area is probably the better, but the two estimates agree closely enough to support one another. The estimated beach-mouse population of the island in the winter

TABLE 1

TOTAL POPULATION OF BEACH-MICE OF THE SUBSPECIES, *Peromyscus polionotus leucocephalus*, AS ESTIMATED FROM THE TRAPPING OF A SAMPLE AREA ON SANTA ROSA ISLAND, FLORIDA

Trapping dates	Number trapped	Estimates of total population	
		From area trapped	From linear distance trapped
Winter:			
Nov. 5–18, 1941	69	10,412	9,270
Nov. 19–Dec. 2, 1941	80	12,072	10,748
Dec. 3–16, 1941	82	12,374	11,017
Dec. 17–30, 1941	117	17,655	15,719
Dec. 31, 1941–Jan. 13, 1942	86	12,977	11,554
Spring:			
May 7–20, 1942	93	14,034	12,495
May 21–June 30, 1942	81	12,223	10,882
June 4–17, 1942	74	11,167	9,942

and spring of 1941–42 was in the neighborhood of 12,000 individuals. There was an increase from an estimated low of 10,412 in early November to a high of 17,655 in late December. The population maintained itself at a surprisingly uniform level during the winter and spring, which suggests that the number of individuals was possibly near the maximum number that the island would support. No evidence is available for the hottest months of the summer, when a decrease in reproduction and a consequent decline in population size might be expected.

We do not mean to infer that the population size remained relatively uniform over a longer time than the periods of field work. Actually, we expect that severe reductions in the population size occur when hurricanes strike the island. Much of the low-lying reef is inundated at such times, and the mortality among the beach-mice must be high.

The total population of the subspecies *leucocephalus*, being confined to Santa Rosa Island, is small by comparison with the populations of most mainland races of small mammals. The deer-mouse (*Peromyscus maniculatus osgoodi*) population of the Black Hills of South Dakota and Wyoming has, for example, been estimated at between 1,000,000 and 5,000,000 individuals (Dice, 1939). This estimate, furthermore, is for only a part of the subspecies population, as *osgoodi* ranges over a much larger area than the Black Hills. In the subspecies *leucocephalus* the breeding population, which is the genetically important fraction of the population (Wright, 1938), was, of course, smaller than the estimated total, for this total includes immature as well as sexually mature animals. The estimated number of sexually

mature beach-mice during the early November low was only 7,847 individuals, and the estimated breeding population during the late December peak was 11,619 individuals.

Perhaps in part because of the relatively small size of this population, the beach-mice of Santa Rosa Island are considerably differentiated from the mainland mice of the same taxonomic species. The subspecies *leucocephalus* differs strikingly from the mainland mice in pattern of pigmentation, as these island mice are white over most of the body (Sumner, 1926). They also differ from the mainland mice in social behavior and in degree of sexual isolation from another species, the deer-mouse (*Peromyscus maniculatus*) (Blair and Howard, 1944). Conditions on Santa Rosa Island are favorable for this differentiation for we have there: (a) relatively small population size, (b) practically complete geographic isolation, and (c) presumed selection by predators toward a beach-mouse that is inconspicuous on the white sands of the island.

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W. Frank Blair

Laboratory of Vertebrate Biology,
University of Michigan, Ann Arbor,
and
Department of Zoology and Physiology,
University of Texas, Austin

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